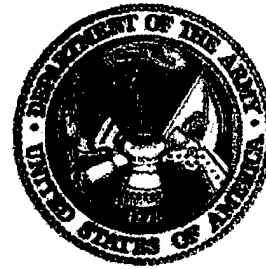
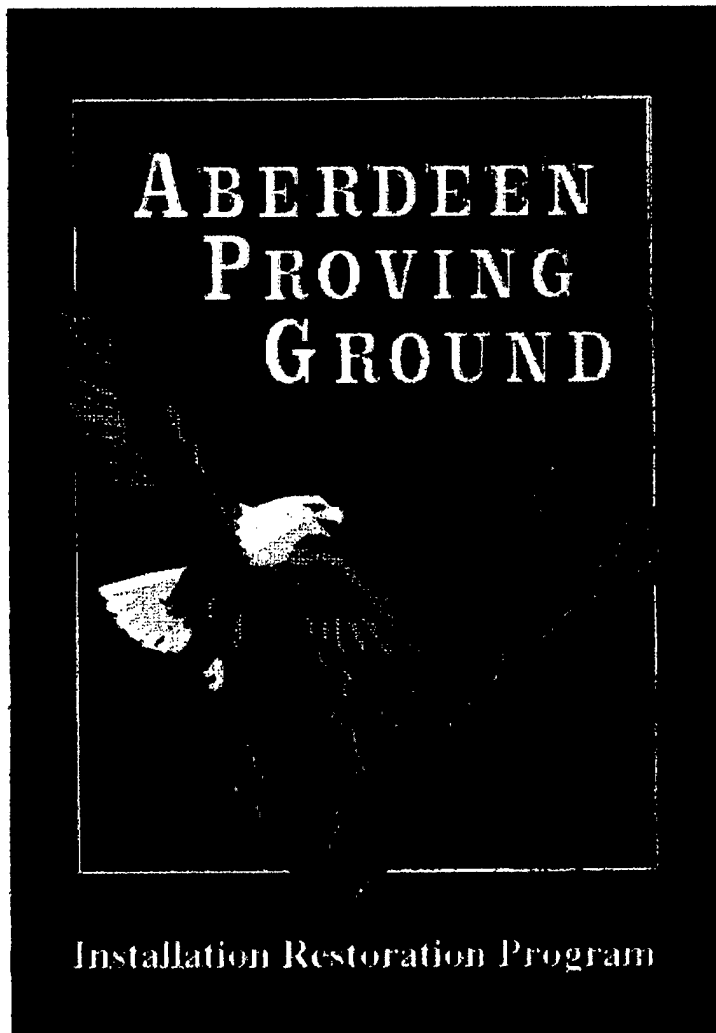


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REFERENCE SAMPLING AND ANALYSIS PROGRAM FIELD OPERATIONS WORK PLAN

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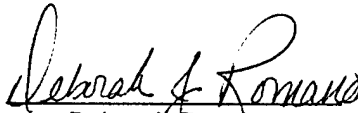
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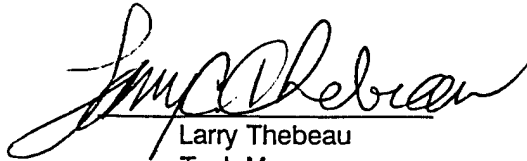
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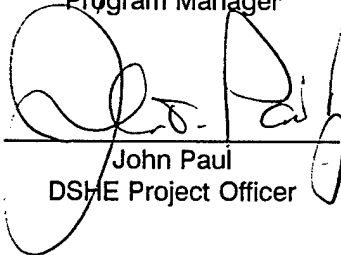
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April 1995

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ADDENDUM

Addendum I	Groundwater Sampling and Analysis
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1.0 INTRODUCTION

ICF Kaiser Engineers (ICF KE) has been contracted by the United States Army Environmental Center (USAEC) to develop and implement a Reference Sampling and Analysis Program (RSAP) at the U.S. Army Aberdeen Proving Ground (APG), Maryland. This task will be performed under Contract No. DAAA15-91-D-0014, Task Order 12. This task was issued for the purpose of providing baseline reference data for Remedial Investigation/Feasibility Study (RI/FS) activities at APG, as well as for the Risk and Biological Impact Assessment (ICF KE 1993) currently under development for the APG Directorate of Safety, Health, and Environment (DSHE). This Field Operations Work Plan (FOWP) describes the technical approach for conducting the field sampling activities, chemical analyses, and data review and analysis associated with the RSAP. A detailed discussion of the Data Quality Objectives, methods of analysis, Quality Assurance Program, and standard operating procedures for the sampling team and laboratory for the RSAP is provided in the Quality Assurance Project Plan (QAPjP) (ICF KE 1995).

This study is being performed under the direction of the U.S. Army, the U.S. Environmental Protection Agency (USEPA) Region III, and the Maryland Department of the Environment (MDE).

1.1 OBJECTIVES

The RSAP objective is collection of reference data for use in the remedial investigation (RI), risk assessment, feasibility study (FS), and environmental remediation decision making processes for APG. The program will address both naturally occurring elements/chemicals and man-made chemicals. Reference chemical data will be collected for soil, sediment, surface water, and groundwater. In addition, at selected locations the benthic community will be qualitatively characterized with respect to composition and relative abundance.

The RSAP data will be used in a variety of planning and decision making efforts. The principal uses will be in:

- determining the minimum number of samples which may be necessary for each combination of analyte, environmental medium, and sampling stratum;
- identifying elements and compounds at a study site which are above background concentrations, may necessitate further sampling and analysis, and are contaminants of potential concern in risk assessment; and
- selecting remedial action strategy and determining appropriate cleanup levels.

Knowledge of background analyte concentrations is important to the success of the RI/FS efforts at APG. The use of the reference data in conjunction with other pertinent information will allow optimization of the RI work efforts such that program objectives are reached without delays or waste of resources.

1.2 CONSTRAINTS

The RSAP is being implemented with a number of technical and management constraints. The principal constraints are:

- The baseline reference data collected must be suitable for conducting both ecological and human health risk assessments;

- The data collected for each media must be representative of the on-post media at APG where RI/FS work is being accomplished;
- Most reference program sampling for chemical analysis must be performed at off-post sites because of the difficulty in verifying that on-post sites have not been contaminated by the numerous and wide ranging historical activities at APG;
- Potential off-site sources of environmental contamination (e.g. landfills, CERCLA sites, industrial activities, underground storage areas) limit potential sampling locations; and
- Written permission for access must be obtained from off-post property owners by the U.S. Army and ICF Kaiser Engineers.

1.3 SCOPE OF WORK

The scope of work for this task includes the following:

- Approximately 30 surface soil samples will be collected and analyzed for Target Analyte List (TAL) inorganics, Target Compound List (TCL) semivolatiles, TCL pesticides, TCL polychlorinated biphenyls (PCBs), hexavalent chromium, dioxins/furans, and radioactive isotopes.
- A total of 100 surface water samples will be collected during two sampling events, one in the spring and the other in the fall. The samples will be analyzed for TAL inorganics and select water quality analytes.
- Sediment samples will be collected at the same 50 locations as the surface water samples during the fall sampling event. The sediment samples will be analyzed for TAL inorganics, TCL PAHs, TCL phthalates, TCL pesticides and PCBs, dioxins/furans, and radioactive isotopes.
- At 20 locations, the benthic community will be qualitatively characterized with respect to composition and relative abundance. No benthic tissue samples will be collected for residue chemical analysis as part of this portion of the RSAP.
- Groundwater samples from approximately 33 wells will be analyzed for TAL inorganics, radioactive isotopes, total uranium, nitrate/nitrite, select anions, total dissolved solids (TDS), and total suspended solids (TSS). All further information on the approach for groundwater sampling and analysis may be found in Addendum I.

All of the field activities and data evaluation will be conducted in accordance with USEPA guidance documents developed for activities performed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization of 1986 (SARA); USAEC technical guidance and quality assurance (QA) requirements; the National Environmental Policy of 1969 (NEPA); and the President's Council on Environmental Quality (CEQ) regulations (40 CFR 1500-1508). In addition, the procedures used in the study are consistent with the Department of the Army's policy toward integrating the NEPA and CERCLA/SARA process.

1.4 ORGANIZATION

The FOWP is divided into five principal sections. Section 2 presents the regional background information on physical setting, climate, physiology, topography, land use, soil types, geology, hydrogeology, and surface water bodies. Section 3 of the FOWP presents the technical approach to achieving the project objectives. Included in Section 3 are discussions of how the reference data will be used in risk assessments, the rationale for the number of proposed samples and the sampling locations, and how the reference data will be analyzed and presented in the RSAP report. The fourth major section of this work plan is a discussion of the field and laboratory procedures for soil sampling, surface water sampling, sediment sampling, health and safety, sample shipment and chain of custody, equipment decontamination, physical and chemical analysis of environmental samples, data management, and disposal of investigation derived wastes. Section 5 of this workplan is a presentation of the project schedule. The approach for groundwater sampling and analysis is presented in Addendum I.

2.0 BACKGROUND

2.1 PHYSICAL SETTING

Aberdeen Proving Ground (APG) is located in northeastern Baltimore County and southeastern Harford County, Maryland on the northwest shore of the Chesapeake Bay (See Figure 2-1). It is bordered to the east and south by the Chesapeake Bay; to the west by Gunpowder Falls State Park, the C.P. Crane Power Station, and residential areas; and to the north by the towns of Edgewood, Magnolia, Aberdeen, and Perryman.

2.2 CLIMATE

The regional climate is classified as humid temperate, with hot humid summers and relatively mild winters. The average temperature is 7° C and an average relative humidity is 74 percent. The average annual precipitation at APG is approximately 45 inches, with maximum rainfall occurring during the summer (Nutter, 1977). Approximately 28 inches of rainfall is lost through evapotranspiration.

2.3 LAND USE

The land surrounding APG is used for farming and industry, but also includes residential areas. Industry is most concentrated along Route 40 throughout Baltimore and Harford County. Residential areas are predominantly new town houses and developments and are located in Harford County. Areas on the eastern shore of the Chesapeake Bay (Eastern Shore) are more agricultural and less populated.

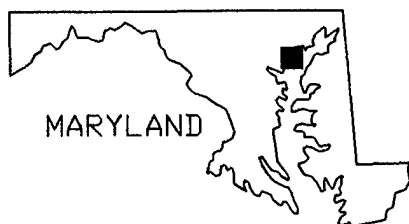
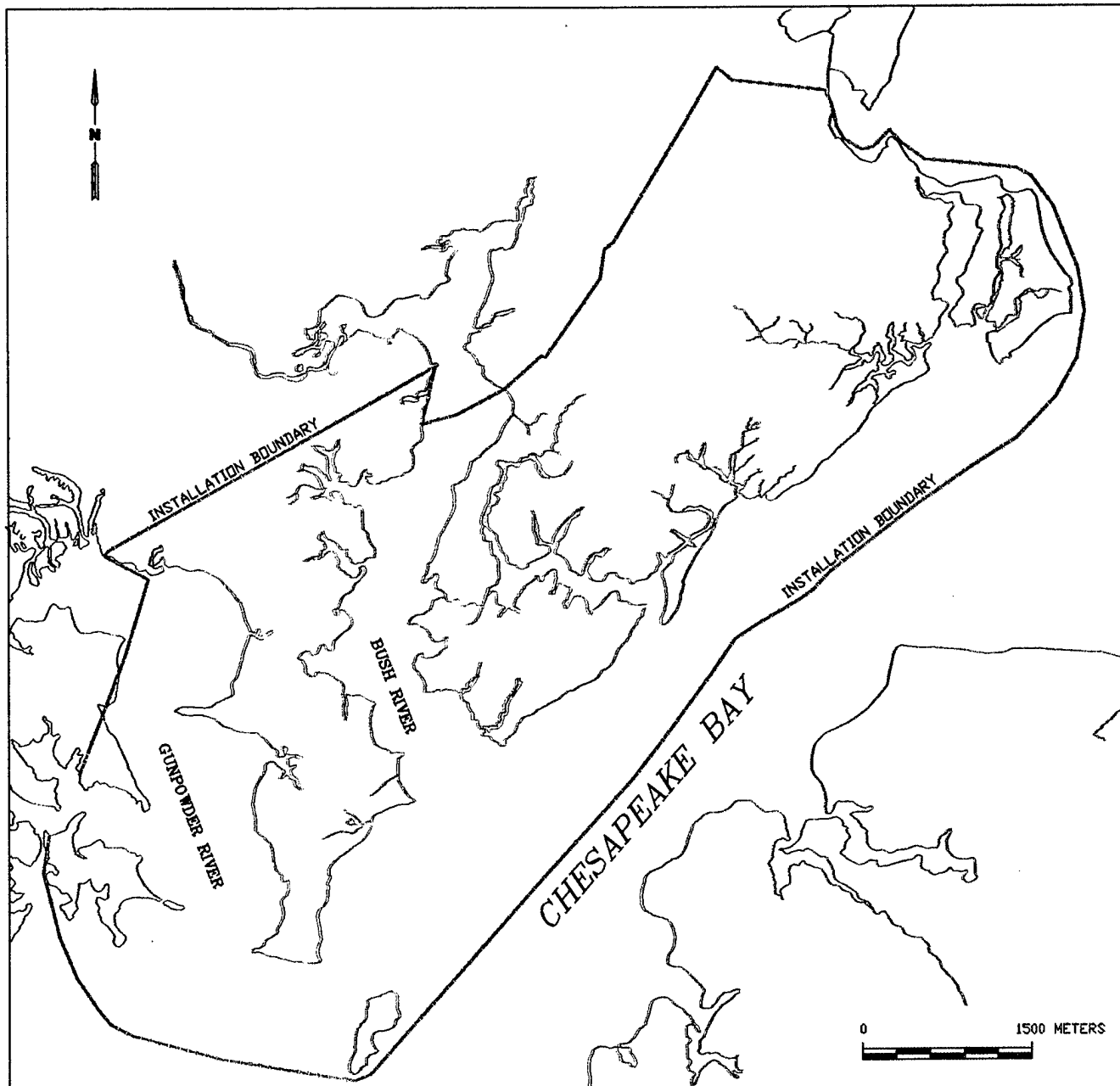
APG is divided into the Edgewood Area and the Aberdeen Area. Historically, the Edgewood Area has supported most of the military chemical warfare research, development, and related activities at APG, whereas the Aberdeen Area has been used as a testing area for conventional weapons, aircraft, and other equipment. With the exception of some industrial and residential areas in the Edgewood Area and the northeastern portion of the Aberdeen Area, most of the land at APG is relatively undeveloped. Approximately 65 percent of the total land area of APG is undeveloped, consisting of extensive woodlands, wetlands, and shoreline bordering the Chesapeake Bay, the Bush River, and the Gunpowder River. A more detailed description of historical and current land use of APG is provided in the Resource Conservation, and Recovery Act (RCRA) Facility Assessments of the Edgewood (Nemeth 1989) and Aberdeen Areas (Derryberry et al. 1990).

2.4 PHYSIOGRAPHY AND TOPOGRAPHY

The region surrounding APG extends across two physiographic provinces, the Piedmont Plateau, and the Coastal Plain. The Piedmont is characterized by rolling to hilly terrain and the Coastal Plain is generally characterized by a low lying, gently rolling terrain. Some areas surrounding the Chesapeake are nearly level while others have been dissected, making the local terrain rolling, to moderately hilly. APG is located within the Coastal Plain and is predominantly low lying along the shores of the Chesapeake. Since the purpose of the RSAP is to provide data for RI/FS studies and the Risk and Biological Impact Assessment at APG, this report will focus on the Coastal Plain Physiographic Province.

2.5 SOIL TYPES

Coastal Plain soils of the region are deep, nearly level to steep, well-drained and moderately well-drained and are underlain by sandy, loamy, gravelly, or clayey sediment on smooth uplands



US ARMY ENVIRONMENTAL CENTER	
CONTRACT NO. DAAA15-91-D-0014	FIGURE 2-1 ABERDEEN PROVING GROUND
ICP KAMER ENGINEERS	1301 Continental Drive Suite 101 Arlington, Maryland 21009 (410) 612-6350
PREPARED KDM	TASK NO. 08232
CHECKED DR	ICP DWG NO:
DATE 02-27-95	APGLOC
LOCATION OF ABERDEEN PROVING GROUND	

(such as Sassafras, Elkton, Beltsville, Loamy and Clayey Land, and Matapeake-Mattapex Series). Soils of the flood plains and low terraces are generally deep, nearly level, well-drained and moderately well-drained and are underlain by stratified alluvial sediment (such as Cordorus, Hatboro, Delanco, and Alluvial Land Series).

The soils found at APG generally are similar to those found in the remainder of the coastal plain areas of the region. The most recent soil survey at APG was conducted in 1927 (Perkins and Winant 1927), and used different classifications than those that are used currently. Based on a comparison of the soil type descriptions, the dominant soils on-site are Sassafras Series, Elkton Series, and Keyport Series. Along most nontidal wetland areas, the Meadow Series (Alluvial Land Series) is dominant, and Tidal Marsh Series is dominant in tidally influenced wetlands. A list of the soil types found at APG and throughout the region is presented in Table 2-1. A more detailed description of regional soils can be found in the Soil Survey for Baltimore and Harford Counties (USDA 1975 and 1976).

2.6 GEOLOGY AND HYDROLOGY

The Coastal Plain sediments consist of marine and non-marine sediments lying unconformably on crystalline rocks of the Piedmont Physiographic Province. They form wedge-shaped deposits which thicken southeastward from the Fall line (which roughly parallels Route 40) to the ocean, with a thickness of between approximately 200 ft and 700 ft below APG (Owens 1969 and Nutter 1977). These deposits include the Potomac Group (consisting of the Patuxent, Arundel, and Patapsco Formations in Harford and northern Baltimore Counties) of Cretaceous age, the upland gravels of Pliocene age, the Talbot Formation of Pleistocene Age, and the recent alluvium deposits (Nutter 1977 and Whitten et al. 1991). In many areas, especially near the Fall Line, the Talbot Formation has been eroded by streams thus exposing the Potomac Group (Lorah and Clark 1992), while along the Chesapeake Bay (for example J-Field on the Edgewood Area of APG, shown on Figure 2-1) the Talbot consists of three separate units (Hughes 1991). A detailed description of the regional geology is provided in Owens (1969), Whitten et al. (1991), Nutter and Smigaj (1975), Nutter (1977), and Otton and Mandle (1984). In addition, geologic references for site-specific studies at APG (whose locations are provided on Figure 2-1) include but are not limited to: Tenbus and Blomquist (1991) for Graces Quarters; Ham et al. (1989) and United States Geological Survey (USGS) (1991) for Carroll Island; Thurman (1992) for Westwood and Bush River Area; Lorah and Clark (1992) and Oliveros and Vroblesky (1989) for Canal Creek; Hughes (1991) for J-Field; Nemoff et al. (1989) for O-Field; USACOE (1992) and AEHA (1990) for the Nike site; Swartzel et al. (1992) and Miller et al. (1990) for Michaelsville Landfill; and Whitten et al. (1991) for the Fire Training Area.

The regional hydrogeology is very complex, heterogeneous, and spatially variable, and it is difficult to correlate the aquifers and confining units; thus only a general discussion is provided herein. Many hydrogeologic studies-- which include the installation of monitoring wells by private contractors, the Maryland Geological Survey (MDGS), the USGS, Baltimore Gas & Electric (BG&E), USACOE, and the Harford County Department of Public Works-- have been conducted in conjunction with powerplant sitings, municipal water supply sitings, investigations of groundwater contamination sources, studies associated with APG activities, etc. In the northeastern (coastal plain) portion of Baltimore County the hydrogeologic studies have focused on areas associated with APG activities. For detailed information concerning these hydrogeologic studies, consult the above-cited references.

Given that RI/FS activities at APG and the Risk and Ecological Impact Assessment have focused (and will focus) on the shallow aquifer system at APG, only this aquifer system of the Coastal Plain (along the northwestern side of Chesapeake Bay) will be discussed. The shallow hydrogeologic system generally consists of a surficial aquifer, an upper confining unit, an upper confined aquifer, a lower confining unit, and a lower confined aquifer.

<p align="center">Table 2-1 Soil Types of the APG and the Nearby Coastal Plain Area</p>	
Region	Soil Type
Edgewood Area of APG ^a	Elkton silt loam Keyport silt loam Sassafras loam Sassafras silt loam Tidal Marsh
Aberdeen Area of APG ^a	Elkton silt loam Keyport silt loam Sassafras loam Sassafras silt loam Tidal marsh Sassafras sandy loam Meadow
Coastal plain upland soils	<u>Beltsville-Loamy and clayey land-Sassafras association</u> Beltsville soils Loamy and clayey land Sassafras soils and other less extensive soils <u>Mattapex-Matapeake association</u> Matapeake soils Mattapex soils Keyport Soils and other less extensive soils <u>Neshaminy-Chillum-Sassafras association</u> Neshaminy soils Chillum soils Sassafras soils and other less extensive soils
Coastal plain flood plains and low terraces	<u>Elsinboro-Delanco association</u> Elsinboro Delanco and other less extensive soils <u>Codorus-Hatboro-Alluvial land association</u> Codorus Hatboro Alluvial land and other less extensive soils

Sources: USDA 1975, and 1976, and Perkins and Winant (1927).

^aSince the most recent characterization of soils at APG in 1927, the soil classifications have changed their nomenclature. As a result, the descriptions provided in the 1927 soil survey have been used to estimate the current soil types present at APG.

The surficial aquifer is unconfined to semi-confined in nature, ranging in thickness from non-existent or lenticular at areas like Grace Quarters (Tenbus and Blomquist 1991) to over 100 ft in Perryman and Michaelsville landfill (Miller et al. 1990, Geraghty & Miller 1983, and ERM 1987). In borings recently completed by the USACOE at Bush River (Thurman 1992), the surficial aquifer is semi-confined in nature. This aquifer ranges in lithology from silty clay to gravelly sand, interbedded in some areas. At Canal Creek, the surficial aquifer is very thick in the paleochannel of the East and West Branch of Canal Creek. Due to its variable nature, the surficial aquifer may consist of all Talbot Formation and recent alluvium (for example at J-Field on APG); part Talbot and part Potomac

Formation; or all Potomac Formation (in areas where the Talbot has been eroded away). Finally, this aquifer is only partially-saturated and near surface water bodies is tidally-influenced.

The upper confining unit, consisting of clay to silt, is described as leaky in nature, and ranging in thickness from non-existent (in the paleochannels of Canal Creek) or very thin to lenticular interbedded with sand in the Perryman/Aberdeen areas (Miller et al. 1990, Geraghty & Miller 1983, and ERM 1987) to approximately 100 ft in thickness at J-Field (Hughes 1991) and the uplands of Graces Quarters (Tenbus and Blomquist 1991). This confining unit is comprised of the upper portion of the Potomac Formation near the Fall Line and the Talbot Formation along the northwestern edge of the Chesapeake Bay (for example at J-Field) (Hughes 1991). At Graces Quarters of APG, the confining unit consists of two separate clay units of the Potomac Group (Tenbus and Blomquist 1991).

The upper aquifer, also called the Canal Creek Aquifer in the Canal Creek area of APG, ranges in lithology from silt to sand and gravel, and is confined to unconfined (at the paleochannel observed at Canal Creek). Reported thicknesses range from 10 ft to 100 ft (USGS 1991 and Hughes 1991), and the aquifer is comprised mainly of the Potomac Group except the southern portion of the study area where it is the Talbot Formation. At J-Field and Graces Quarters this unit has been reported as alternating silty clay units (Hughes 1991, Tenbus and Blomquist 1991).

The lower confining unit ranges in lithology from clay of the Potomac Group (Miller et al. 1990) to interbedded clay to fine sand of the Talbot Formation at J-Field (Hughes 1991). This confining unit has been reported as ranging in thickness from 15 ft near the Fall Line (Drummond 1993) to 65 ft (Tenbus and Blomquist 1991 and Hughes 1991). The lower aquifer, which is confined in nature, ranges in lithology from fine to medium sand sometimes interbedded with clay. The thickness of this unit has not been well defined in the available hydrogeologic studies.

2.7 SURFACE WATER

Regional surface waters in Baltimore County, Harford County, and Cecil County on the Eastern Shore include both freshwater and estuarine systems and consist of rivers, estuarine creeks, freshwater creeks, estuarine marshes, freshwater marshes, freshwater ponds, and ephemeral ponds. Regional surface water flows toward the Chesapeake Bay following the topography. Flow and volume in major rivers of the region ranges widely.

The salinity in the estuarine systems surrounding APG ranges from fresh water to approximately 5 parts per thousand (ppt) and varies seasonally. On the Eastern Shore conditions are slightly more saline due to the coreolis effect. Based on limited studies, the estuarine rivers surrounding APG show little stratification (Magnien et al. in prep.).

The sediments of the creeks and rivers that drain into the Chesapeake Bay range from mucky bottoms in low flowing areas, to sandy cobbled bottoms in rapidly flowing brooks and streams. Most of the tidal creeks and rivers in the coastal plain are underlain by Tidal Marsh soils which range from sandy silts to silty sands. The sediments of the Chesapeake Bay surrounding APG have not been characterized. Preliminary investigations suggest that the substrata range from gravels, sands, and silty sands near the shorelines to silts in deeper less disturbed areas (ICF KE 1993).

The flow, salinity regimes, and lithology of bottom sediments of on-site surface waters are all similar to those of the rest of the region. A more detailed description of on-site conditions is presented in the appendices of the general Technical Plan (ICF KE 1993).

3.0 TECHNICAL APPROACH

3.1 GENERAL

3.1.1 Environmental Media

The RI efforts at APG will involve characterization of contaminant concentrations in soil, sediment, surface water, and groundwater. The risk assessments will consider risks associated with contaminants in all of these media and therefore, all of these media will be addressed by the RSAP. The risk assessments will also address respiratory exposure to contaminants present in air as particulates and gas/vapor. The RSAP will not address air because:

- Air monitoring, other than Level 1 monitoring for health and safety reasons, will not be accomplished during most RI efforts. Rather, air contaminant levels and expected respiratory exposure will be modelled by risk assessors using contaminant data for soil, surface water and soil gas.
- Regional air quality is temporal in nature because of high mobility of air contaminants, variability in emission rates, and variable wind conditions. Because of the temporal nature of regional (background) air quality, upwind (local background) air monitoring during any RI air monitoring efforts will be necessary to provide data for risk assessment.

The environmental media at APG are heterogeneous in nature and the concentrations of naturally occurring and ubiquitous man-made constituents are expected to vary within a particular media. While part of the variation is random, a portion of the variation will also be systematic due to factors such as specific characteristics of media. For example, some soil element concentrations may depend on soil types, and surface water element concentrations may be related to both drainage basin soil types and tidal zone influence. The RSAP must define the relevant population groups for each media and identify those media characteristics upon which element/chemical concentrations are dependent.

3.1.2 Analyte Selection

The risk assessment efforts and therefore the RSAP will address both naturally occurring elements and anthropogenic chemicals. The combined naturally occurring levels and anthropogenic levels will be determined. Ubiquitous background concentrations will be determined for anthropogenic compounds, as opposed to local background levels. Ubiquitous contaminants in soil are contaminants that have been transported from distant or non-point sources by air. Transport of ubiquitous contaminants in sediment will have been via both surface water and air. Local on-post background concentrations which are higher than ubiquitous concentrations will be assumed to originate from a local source on or adjacent to APG and will be addressed by upgradient sampling and analysis as part of the individual remedial investigation efforts.

All elements are naturally occurring¹, some are anthropogenic contaminants, and some are also expected to be environmental contaminants at many of the RI/FS study sites at APG. Therefore, all Phase 1 samples for all media will be analyzed for TAL inorganics.

¹The exception to this is the synthetic radionuclides in the Lanthanum and Actinium series.

CONTAMINANTS in the ENVIRONMENT

The presence of an element in a particular environmental sample may be attributed entirely to natural occurrence, or a portion of the element may be present because of **anthropogenic** factors, that is, present because of human activities. Like the elements, some organic compounds are **naturally occurring**, but most are anthropogenic. Polynuclear aromatic hydrocarbons (PAHs) are an example of naturally occurring organics which are also contributed to the environment as a result of anthropogenic factors. That portion of an element or compound which is present because of anthropogenic factors is commonly referred to as pollution or contamination.

Some contaminants are **ubiquitous** in the environment. That is, they are widespread and constantly encountered. Ubiquitous environmental contaminants have certain characteristics in common:

- All ubiquitous contaminants have release and transport mechanisms which result in widespread distribution in the environment. These contaminants are most commonly released to and transported by air. Some are discharged to and transported by surface water.
- Ubiquitous contaminants are generally persistent in the environment.

The PAHs and dioxins are examples of ubiquitous contaminants. Both of these classes of compounds are released by combustion processes, are transported large distances by winds, and are deposited over broad areas, often in conjunction with precipitation. These compounds are also persistent in the environment and are found in surface soils and sediments because of high soil/water partition coefficients.

The concentration of a ubiquitous contaminant in a sample will be determined by the sum of the contribution from regional sources and from local sources. The levels in the environment due only to regional anthropogenic sources and any natural occurrence are the **regional background concentration**. Contaminant sources near, but independent of, a study area can cause localized higher concentrations, with these commonly being referred to as **local background**.

The concentrations of naturally occurring elements/compounds and also contaminants in a particular media sample can be related to the media characteristics or classification. For example, the concentration of lead in soil may be related to grain size and soil type. Soils of similar type and grain size which have similar lead concentrations form a **population group**. There may be several population groups for a particular analyte and media, with background concentration for each being different.

Inorganic anions are not expected to present significant risks at most of the RI/FS study sites. However, these anions and certain water quality parameters can be a valuable tool in understanding and defining population groups for both groundwater and surface water. Table 3-1 lists these water quality parameters and other analytical parameters for each media.

Polynuclear aromatic hydrocarbons (PAHs) and dioxins/furans are anthropogenic compounds which have been released to all environmental media as contaminants, including the air. They are ubiquitous in the environment as a result of air transport (Helz and Huggett, 1987). These compounds also have very low water solubilities and high partition coefficients between soil or sediment and water. Because of these characteristics, these compounds are often found at low

Table 3-1 Reference Sampling and Analysis Program Analytes			
PARAMETER TYPE	SOIL	SEDIMENT	SURFACE WATER
Naturally Occurring	TAL inorganics Hexavalent Chromium	TAL inorganics	TAL inorganics
Anthropogenic compounds	gross alpha/beta TCL pest/PCBs TCL semivolatiles dioxins/furans	gross alpha/beta TCL pest/PCBs TCL PAHs ^a dioxins/furans TCL phthalates ^a	
Media Characterization	pH Grain Size Distribution USCS Classification Atterberg Limits Percent Moisture Organic Matter Content	pH Grain Size Distribution USCS Classification Atterberg Limits Percent Moisture Organic Matter Content	pH temperature conductivity alkalinity hardness TDS TSS COD

^aTCL polynuclear aromatic hydrocarbons (PAHs) and TCL phthalates are a subset of the TCL semivolatiles.

concentrations in soil and sediment where they tend to accumulate, and are not detected in groundwater or surface water. All Phase 1 soil and sediment samples will be analyzed for TCL PAHs and half of these samples will be analyzed for the dioxin/furan homologous series.

Phthalates are also anthropogenic compounds which can be ubiquitous in the environment. These compounds are commonly released to the environment in wastewater or via leaching from solid waste disposal sites. Phthalates can be adsorbed to and remain in sediments as a result of historical release to surface water. All Phase 1 sediment samples will be analyzed for TCL phthalates. Because of the release and transport mechanisms for phthalates, detection of these compounds in soil or groundwater at RI/FS study sites will suggest that either the study site is the source or that there is an upgradient source. Detection of phthalates in surface water at the RI/FS study sites will probably indicate that there is ongoing transport from a source at either the study site or an upgradient site (on-post or off-post). These possible situations must be addressed by upgradient sampling as part of the individual RI efforts.

Certain environmentally persistent pesticides have been widely used and are now ubiquitous in the environment in many regions. The compound 1,1,1-trichloro-2,2-bis(4-chlorophenyl)-ethane (4,4'-DDT) is an example of such a pesticide. 4,4'-DDT has been widely used for purposes such as mosquito control both on APG and in surrounding areas. The environmentally persistent pesticides typically have low water solubilities and are most commonly found in soil and sediments. All Phase 1 reference samples from these media will be analyzed for environmentally persistent chlorinated pesticides.

Polychlorinated biphenyls (PCBs) are another class of compounds known to be anthropogenic contaminants of Chesapeake Bay sediments (Helz and Huggett, 1987). PCBs are similar to organochlorine pesticides in their environmental behavior, with very low water solubility and very high

sediment/water partition coefficients. All Phase 1 soil and sediment reference samples will be analyzed for PCBs.

Radiochemicals in the environment can be either naturally occurring or anthropogenic. Historical release of anthropogenic radiochemicals to the environment has been to both air and surface water. Approximately half of the Phase 1 soil and sediment samples will be analyzed for gross alpha and gross beta radioactivity.

3.1.3 Contaminant Levels of Concern

The planning for this project included identification of levels of concern for each analyte in each media in which background concentrations are being determined. The purpose in identifying conservative contaminant concentrations of concern is to allow selection of analytical methods with appropriate detection limits and to identify those analytes requiring the largest number of samples to support the required statistical testing.

An exposure scenario for humans based on residential land usage has been used in identifying conservative concentrations of concern in soil (EPA 1994). Chronic freshwater ambient water quality criteria (EPA 1991) and recreational swimming are used to identify concentrations of concern in surface water for biota and humans, with the water quality criteria for protection of aquatic life being lower for most elements. The "Effects Range-Low" (ER-L) values for biological effects reported by Long et al. (1993) and the National Oceanic and Atmospheric Administration (NOAA) (Long and Morgan 1990) are used as concentrations of concern for sediments.

3.1.4 Chemical Analysis Methods and Detection Limits

All chemical analyses of soil, sediment and surface water samples will be performed using EPA methodology. The baseline methodology for TAL analytes and TCL compounds will be based on the Statement of Work in the Contract Laboratory Program (CLP). The analytical methodology is discussed further in Section 4 of this Work Plan and in the QAPjP.

The factors considered in selecting specific analytical methods for the RSAP included: (1) the need for detection limits to be at least as low as the concentrations of concern, (2) consistency with the approach for the overall APG CERCLA program, including QA/QC documentation, and (3) the need to use routine methodology to avoid very large cost impacts on the APG CERCLA program. Given these considerations, EPA CLP methodology was chosen for TAL analytes and TCL compounds. Adequately low detection limits can be obtained for TAL metals using the CLP methods, with graphite furnace methods being necessary for some elements often analyzed using ICP methods. The routine CLP methods do not provide detection limits as low as sediment concentrations of concern for some pesticides. There are no currently available production type methods of analysis for pesticides with quantitation limits lower than concentrations of concern in sediment for all such compounds. It should be noted that while the RSAP does not include analysis of surface waters for pesticides, the concentrations of concern in surface water are also lower than quantitation limits for some such compounds.

The implications to the APG CERCLA program caused by not being able to quantitatively detect certain pesticides in sediment at the very low concentrations of concern are believed to be minor because:

- Only two pesticides, dieldrin and endrin, have levels of concern substantially lower than detection limits. For some other pesticides, including chlordane, toxaphene and DDT, the detection limits are in the same approximate range as the levels of concern.

ANALYTICAL DETECTION AND QUANTITATION LIMITS

There are a variety of commonly used terms in EPA methodology to describe analytical detection and quantitation limits (EPA 1992). Some of these include:

Instrument Detection Limit (IDL). The IDL includes only the instrument portion of detection, not sample preparation, concentration/dilution factors, or method-specific parameters.

Method Detection Limit (MDL). The MDL is the minimum amount of an analyte that can be routinely identified using a specific method. The MDL can be calculated from the IDL by using sample size and concentration factors and assuming 100% analyte recovery. In addition, the MDL can be determined relative to the extraction such that the MDL reflects the entire analytical sequence, including the analyte recovery. The similarity of the matrix used for MDL determination to the actual sample matrices determines the degree to which the MDL is representative of the detection limit for environmental samples.

Sample Quantitation Limit (SQL). The SQL is the MDL adjusted to reflect sample-specific action such as dilution or use of a smaller sample aliquot for analysis due to matrix effects or the high concentration of some analytes.

Limit of Quantitation (LOQ). The LOQ is the level above which quantitative results may be obtained with a specified degree of confidence.

Contract Required Quantitation Limit (CRQL). The CRQL for organics and contract required detection limit (CRDL) for inorganics are related to the SQL that has been shown through laboratory validation to be the lower limit for confident quantitation and to be routinely within the defined linear ranges of the required calibration procedures on an inter-laboratory basis. When the term "detection limit" is used with respect to CERCLA methodology, it is normally the CRQL (or CRDL) which is being considered.

Analytes detected above the MDL are accepted as being present in the sample with at least a 99% confidence. The quantitation of analytes detected above the MDL but below the CRQL are not known with the specified degree of accuracy for the method, with the level of uncertainty greatest for concentrations near the MDL. The MDL is generally lower than the CRQL by a factor of two to five for analyses identified by mass spectrometry or with dual column confirmation. The presence of analytes within this range will be quantitated by the laboratory and reported as an estimated concentration.

- There is no information to indicate that there was substantial production, testing, or other activities outside of normal usage causing release of these pesticides to the environment at APG. Previous environmental study work at APG has not provided indication that these pesticides are significant contaminants or problems at APG.

A limited range of options exist for maximizing the utility of the data which will be obtained and minimizing the impact of data censoring caused by high detection limits. These options are discussed in Section 3.2.6.

3.1.5 Reference Data Use in Risk Assessments

Reference data are used in risk assessments in the screening process to identify inorganic elements which are present above background concentrations and may be of potential concern. Inorganic elements which are not determined to be present above background levels are normally screened from the human health risk assessment process. Ubiquitous anthropogenic organic compounds may also be screened from the assessment based on comparison to background concentrations. The determination that an element or chemical is not statistically above background does not necessarily mean that the chemical will be automatically eliminated from the risk assessment. Such chemicals may more appropriately be considered separately in the risk assessment, rather than be eliminated from consideration. Ubiquitous anthropogenic organic chemicals in particular will be carefully considered before elimination from the assessment.² For example, if release of such a compound was known to occur at a particular study site, it would be carried through the risk assessment process even if site concentrations are not higher than background. The situation of contaminants causing risk, but at levels within background concentration ranges, would then be considered in decision making processes related to remediation and protection of health and environment.

Study site data are compared to appropriate reference data using statistical analysis. The statistical procedure commonly used is the t-test, or Cochran's approximation to the t-test.³ The comparison should be made to a reference group with the same population characteristics. For example, the reference soils should be of the same type (soil series, grain size distribution, percent organic carbon, etc.) as the particular study site. The number of appropriate reference samples and study site samples must be adequate to detect desired relative differences with specified confidence level and statistical power. The relative difference which must be discernable is that between the reference concentration and the concentration which represents an unacceptable risk (concentration of concern). The relative differences are different for each compound and exposure scenario. Furthermore, because population variability is not yet known, the number of necessary reference samples (or study site samples) cannot be stated with certainty. For this reason, a two phase sampling program is necessary to assure adequate determination of reference concentrations for risk assessment.

The levels of error proposed for APG risk assessment comparisons of RI site data to background data are 5% for both Type I and Type II errors (Refer to text box for a discussion of statistical testing errors). Confidence levels and power of 95% are considered to be relatively high and ambitious and may be a factor in forcing additional sampling and analysis during both this reference sampling program and also during RI studies.

²Anthropogenic organic compounds which are not known to be ubiquitous in the environmental media being evaluated are not compared to a reference background and are not screened from the risk assessment by this process. Organic compounds not suspected to be ubiquitous environmental contaminants are not addressed by the RSAP.

³For the t-test to be valid, it must be assumed that the population is normally distributed and that the population variance for the study site and reference site are equal. While these assumptions are often not valid, the t-test is still commonly used in risk assessment statistical analysis.

STATISTICAL TESTING ERRORS

The null hypothesis for the statistical comparison of RI site data to background data can be stated as "analyte concentrations at the study site are equal to or less than background concentrations." The alternative hypothesis can be expressed as "analyte concentrations are higher at the study site." Performing a statistical comparison and wrongly concluding that study site concentrations are higher than background when in fact they are not is termed **Type I** error. The probability of a Type I error is α and is called "level of significance", while the "confidence level" of a test is $1-\alpha$. A **Type II** error occurs when wrongly concluding that study site contaminant concentrations are not higher than background concentrations when in fact they are higher. The probability of a Type II error occurring is β and the "power" of a statistical test is $1-\beta$. Simply stated, Type I error can result in performing unnecessary additional investigation and remediation work when such work is not necessary, and Type II error can lead to the failure to adequately address a situation where study site contaminant levels are actually above background. Acceptable Type I and Type II errors in remedial investigation and feasibility study work are 0.05 to 0.10 (5% to 10%) when human health risks are considered. Acceptable error levels when ecological impacts are considered are normally higher, and can be as much as 20% in some situations. The EPA recommended minimum confidence and power for risk assessment purposes are 80% and 90%, respectively (EPA 1992).

3.1.6 Reference Site Selection

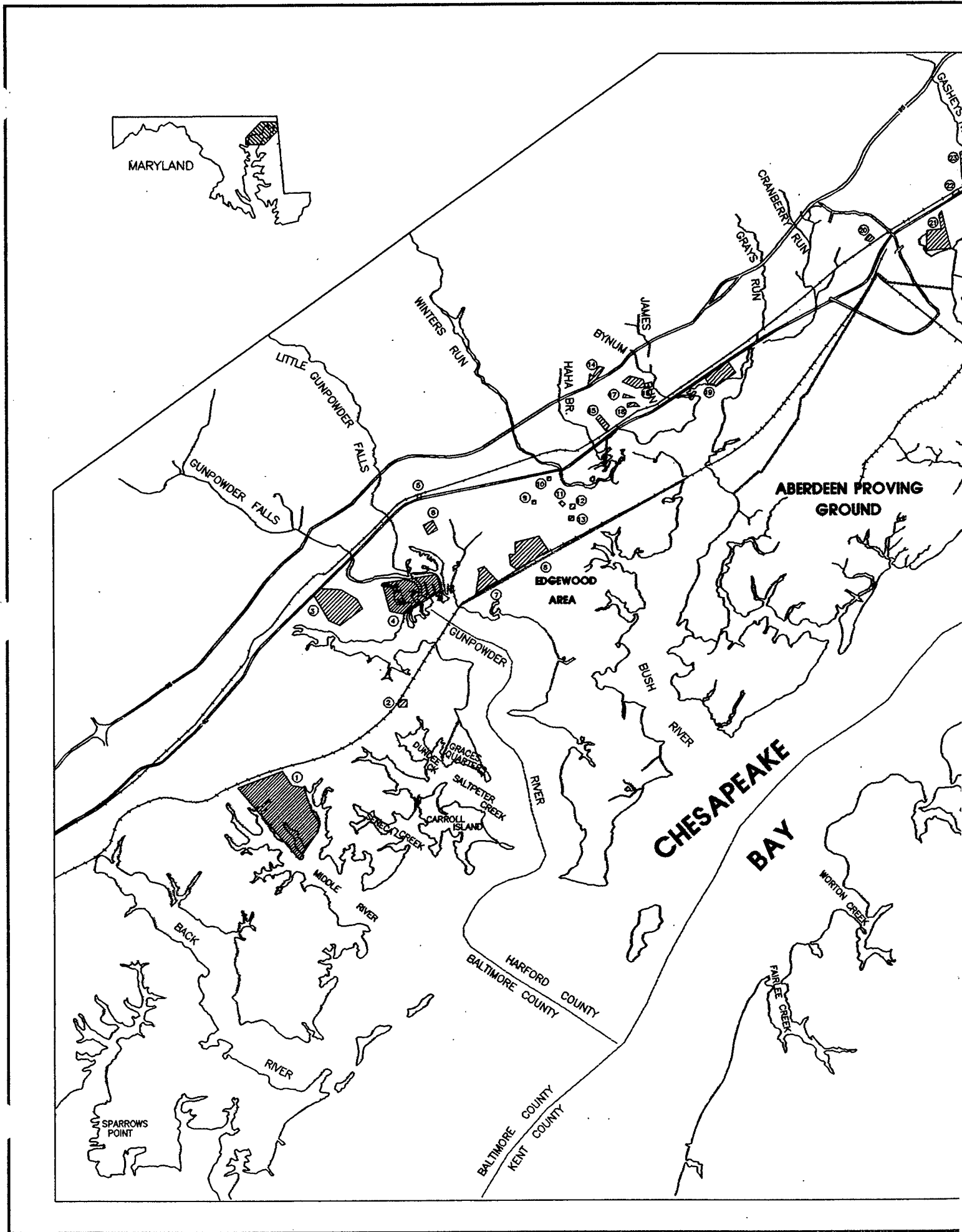
The two major objectives which must be achieved when selecting reference sampling locations are:

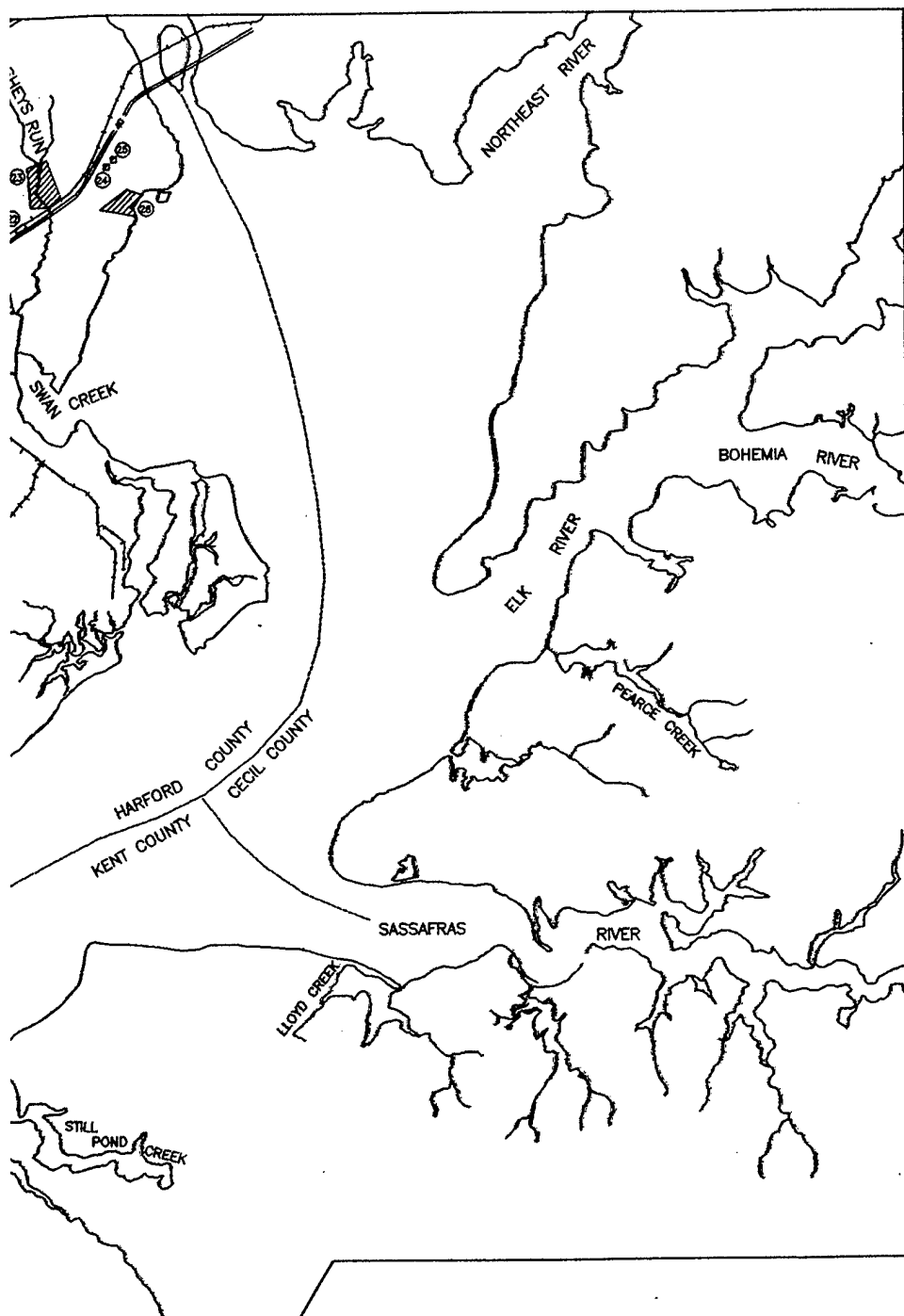
- Adequately representing on-post environmental media, and
- Measuring regional background analyte concentrations while avoiding areas with locally higher concentrations due to contaminant sources.

The first of these objectives will be addressed in this project by comparing relevant population parameters for reference sites to those for on-post study areas. General population parameters have been evaluated in selection of the reference sampling locations identified in this plan. For example, soil classifications have been evaluated to ensure that soil types believed to exist at on-post study sites are sampled at off-post reference locations. After reference samples have been collected and analyzed, physical properties such as grain size distribution will be compared to such properties for study sites to ensure that reference data are used appropriately. The issues of media comparability are further discussed for each media in following paragraphs of this workplan section.

The second objective, avoiding the use of data from reference locations which have been contaminated by local contaminant sources, will be achieved by first attempting to avoid contaminated sites, and second by screening of unacceptable data from the reference data sets.

Reference sampling locations have been selected after careful investigation to identify and avoid possible sources of local contamination. Landfills, sludge landfarming fields, incinerators, industrial facilities, commercial developments, septic systems, service stations, and other fuel or underground storage tank sites are all potential contaminant sources which have been avoided. Potential areas of contamination are present throughout Harford and Baltimore County. Areas of particular concern include various landfills and sludge disposal areas, the Bata Shoe Company in Perryman and American Cyanamid Corporation in Havre de Grace. The largest areas of potential concern are presented in Figure 3-1.





POTENTIAL SOURCES OF CONTAMINATION	
1	GLENN L. MARTIN STATE AIRPORT
2	J & L INDUSTRY INC.
3	SANITARY LANDFILL
4	RUBBLE LANDFILL
5	LEAKING UNDERGROUND STORAGE TANK
6	RUBBLE LANDFILL
7	HARFORD SANDS INC.
8	SLUDGE DEPOSITION AREA
9	LEAKING UNDERGROUND STORAGE TANK
10	LEAKING UNDERGROUND STORAGE TANK
11	LEAKING UNDERGROUND STORAGE TANK
12	LEAKING UNDERGROUND STORAGE TANK
13	LEAKING UNDERGROUND STORAGE TANK
14	RUBBLE LANDFILL
15	ABINGTON LANDFILL
16	BUSH VALLEY LANDFILL
17	DISPOSAL AREA
18	RUBBLE LANDFILL
19	BATA SHOE
20	DIAMOND OIL COMPANY
21	MULLINS LANDFILL
22	GETTY OIL
23	SLUDGE DEPOSITION
24	LEAKING UNDERGROUND STORAGE TANK
25	LEAKING UNDERGROUND STORAGE TANK
26	AMERICAN CYANAMID

LEGEND

- COUNTY LINE
- MAJOR ROAD
- - - INSTALLATION BOUNDARY
- + + RAILROAD TRACKS
- ▨ POTENTIAL SOURCES OF CONTAMINATION (NON-APG)
- ⑥

0 5000 FEET 0 1500 METERS

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DAAA15-91-D-0014

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CHECKED DR

ICF DWG NO:

DATE 02-08-95

REFSAMP3

FIGURE 3-1

ABERDEEN PROVING GROUND

POTENTIAL AREAS
OF ENVIRONMENTAL
CONTAMINATION

After reference data have been collected, the data sets will be examined to identify any sampling sites at which measured element/compound concentrations may have been influenced by unknown or unanticipated local contaminant sources. Where local sources have significantly affected measured concentrations, such data will not conform to the pattern established by other measurements in the data set. Both judgement and statistical techniques will be used to identify such outliers. Outlier data will be rejected and not used in establishing regional background concentrations of analytes. The outlier analysis to be performed is discussed in Paragraph 3.2.4 of this workplan.

3.2 ANALYSIS OF REFERENCE DATA

3.2.1 General

The following general practices will be used in the evaluation of the reference data:

- For non-detect results, one half of the sample- and chemical-specific detection limit will generally be used to represent the concentration in that sample.
- Field duplicate sample results will be averaged together and the average will be used thereafter as the reference concentration for that sampling location/time.

Estimated concentrations ("J" flagged data) may be used for selected analytes in certain media. One half of the SQL, instead of one half the CRQL or CRDL, will be used to represent non-detects for the majority of analytes in surface water, sediment, and soil. These analytes and media combinations are those where the concentration of concern is near to or less than the CRQL (or CRDL) for the CLP analytical method. The selection of analytical methodology and detection limits was discussed in Section 3.1.4 and the evaluation of potential impacts of using censored data sets is discussed in Section 3.2.5.

3.2.2 Use of Existing Data

Existing data from published environmental study work and remedial investigation work at APG have been reviewed to assist in planning this reference sampling program. This existing data will also be used when the reference program data are analyzed and interpreted. With certain exceptions, such existing data will not actually be used as a part of the reference program database in calculating background concentrations of elements and anthropogenic compounds. The reasons for not using such data include:

- Data from on-post study sites generally cannot be used because of concerns that the sampling site may be contaminated.
- Data generated for off-post sites by studies not having a rigid QA/QC program cannot be validated.
- Locations of sampling sites for many studies often cannot be precisely determined, and it is therefore difficult to know the characteristics of the particular media where samples were obtained. It is also impossible to know or verify that the site has not been impacted by local contaminant sources.

Existing data which may be used by the reference program include off-post reference data generated by various RI studies and on-post ground-water quality data from monitoring wells believed to be located in uncontaminated upgradient areas. This use of existing data will be further discussed in Sections 3.4 through 3.6 of this plan.

3.2.3 Media Population Groups

It is anticipated that analysis of the reference data for each type of media will identify population groups within which the concentrations of an element/compound are similar. These population groupings may be based on either defined types for a particular media (i.e. soil type) or on certain media characteristics. Population types for each environmental media are discussed in greater detail later in this workplan section. Media characteristics are also expected to be important in establishing population groups for the reference data. Examples of media characteristics upon which element or compound concentrations may be dependent include grain size for soil and sediment and salinity for surface water. Environmental media characteristics expected to be a factor in defining element concentrations are also discussed in greater detail in following paragraphs of this workplan section.

Statistical analysis of variance (ANOVA) will be performed with the reference data to determine if a relationship exists between analyte concentrations and defined media types and media characteristics. The analysis and presentation of the reference data and the degree to which population grouping is appropriate is expected to be different for the various organic and inorganic analytes. Where there is a large percentage difference between background environmental concentrations and levels which would represent unacceptable human or ecological risk, there will be little need for presenting the data for individual population groups. The anticipated usage of the reference data will be the primary consideration in analysis and presentation of the reference data.

Where samples are collected from the same location at different points in time, the data sets will be first treated as independent, handled separately, and will be analyzed to determine if there are seasonal variations in the reference concentrations. If seasonal variations are determined to exist, the relative difference between the maximum seasonal concentrations and conservative case risk problem levels will be evaluated to determine if seasonal variations must be considered during this reference sampling program data analysis and also during risk assessments to be performed. It is expected that seasonal variations would be seen only for surface water and groundwater, and only these media will be sampled more than once to address these possible variations.

3.2.4 Outlier Analysis

Outliers are observations in a data set which do not conform to the pattern established by other observations in the data set. Outlier analysis will be performed to screen from the reference data sets that data for which measured concentrations of elements/compounds have been significantly influenced by unanticipated and unknown local contaminant sources. Both statistical methods and judgement will be used to identify outliers. The outlier analysis will also serve as a data assessment step to identify observations in the reference database which are erroneous because of problems or mistakes in analysis and data management and which have not been detected by project QA/QC procedures.

The statistical procedure which will be used to identify possible outliers in data sets containing at least 25 data points is that of Rosner (1983). Rosner's (1983) "many outlier" sequential procedure can be used to identify up to 10 possible outliers and can be used for data with either a normal or lognormal population distribution. When Rosner's test is applied, the level of significance which will be used is $\alpha=0.05$. For data sets with less than 25 data points, the test procedure of Dixon (1953) will be employed.

No data will be discarded solely on the basis of a statistical test. Caution will be used to ensure that data are not screened from the reference data set when what appears to be an outlier is actually not (the probability of such an occurrence is the α level of the test), or when the data are

actually not affected by a local contaminant source but are rather part of a previously unidentified population group with different population parameters. The sampling and analysis data, the sampled media characteristics and population grouping, and the location of the site will be examined in an attempt to find a plausible explanation to warrant exclusion of the datum point as an outlier. The steps which will be taken to evaluate the possible outlier will include:

- The sample characteristics will be compared to sample characteristics for the other samples in the same population group. For example, if the sample is of soil or sediment, the grain size and organic carbon content of the sample will be compared to other samples. If comparisons such as this show the sample to have different characteristics, the datum may not be an outlier, but rather the sample may be part of a different population group.
- The other chemical analysis data for the sample will be examined. While elevated concentrations of other elements or compounds may be indicative of an inappropriate population grouping, it may also suggest the presence of a local source of contamination which has impacted the reference sampling location.
- The reference sampling location will be re-examined in an attempt to identify possible local sources of contamination nearby or upgradient of the reference location.

The handling of the datum which may be an outlier will depend on the findings of these evaluation steps. If no local source of contamination is identified as a plausible explanation and if placement of the sample in a different population group is not considered appropriate, then the impact of use of the datum in the reference data set will be evaluated. If the datum cannot be either excluded or included in the reference data set without significant effect on the utility of the data set, resampling will be considered.

3.2.5 Population Distribution Analysis

In many cases the distribution of concentrations of elements and contaminants in the environment is skewed and the normal distribution is not a suitable model for estimating means and other population parameters. Many of the statistical tests and procedures commonly used in evaluating and comparing data sets are based on the assumption that the data are normally distributed. For example, the t-test, which is used in the EPA-defined risk assessment process to compare site data to background data, assumes that the data are normally distributed.

Goodness-of-fit tests will be performed with the reference data sets to test the hypothesis that the data are normally distributed. The W test (Shapiro and Wilk 1965) and D'Agostino's test (D'Agostino 1971) will be used to test the hypothesis of normality for sample sets of 50 or fewer data points and for sets of more than 50 points, respectively. While environmental concentrations are often not normally distributed, the lognormal distribution is commonly a very good model for such data. When populations are lognormally distributed, the data can be transformed and all of the classical statistical procedures then applied, including the t-test. The W test and D'Agostino's test will be used to test the hypothesis of a lognormal distribution. If neither the normal or lognormal distributions are suitable models for certain reference data sets, various nonparametric tests will be used to evaluate the reference data and the potential impacts of using statistical procedures assuming normality.

3.2.6 Analysis of Censored Data Sets

It is anticipated that for a number of reference program analytical parameters, the concentration in many reference samples will be less than the detection limit of the analytical

procedure. For non-detect results in environmental data sets used in risk assessments, one half of the sample- and chemical-specific quantitation limit is normally used to represent the concentration in those samples. Data sets with some or many non-detects are commonly referred to as "censored" data sets. For parameters where many or most of the analytical results are non-detects, the use of one half the detection limit can bias the estimates of population mean and variance, and therefore, affect the outcome of comparisons between study site and background data sets. The use of biased estimates of population parameters may be acceptable for elements or compounds for which detection limits are low relative to concentrations of concern. However, where the relative difference between detection limit and concentration of concern is small, such as for carcinogenic metals and some pesticides, unbiased estimates of population parameters may be important. The reference data will be analyzed to evaluate the impact of using half of the detection limit in statistical procedures. The most straightforward method of evaluating the impact of censoring will be to perform a sensitivity analysis to evaluate the sensitivity of population parameter estimates to fraction of detection limit used for non-detect results.

There are certain actions which can be taken to maximize utility of the analytical data for those elements/compounds which have quantitation limits near the concentrations of concern. Estimated concentrations ("J" flagged data) which are between the method detection limit (MDL) and the contract required quantitation limit (CRQL), instead of one half the CRQL, may be used in determining background concentrations of some elements/compounds in various media, including some pesticides in sediment. The common approach of using one half the CRQL simply assumes that we know nothing about the analyte presence, absence, or concentration, and that all concentrations between zero and the CRQL are equally likely to occur (uniform probability distribution). The use of estimated concentrations when the analyte is detected at a concentration between the SQL and the CRQL is clearly better than assuming a concentration of one half of the CRQL when handling non-detect data and is appropriate in establishing reference background concentrations.

The method detection limit (MDL), or the associated SQL, is the level at which the risk of a false positive is 1% and the risk of a false negative is 50%. The probability of detection is 50% when the analyte is actually present at a concentration equal to the MDL/SQL. Under ideal (not real world) circumstances this would make the SQL a better estimator of actual concentration in a non-detect situation than is one half of the CRQL (or CRDL). EPA guidance also indicates that the SQL is the most relevant quantitation limit for evaluating non-detected chemicals, and that with proper interpretation, data with estimated concentrations may be used in decision making (EPA, 1992). The real world limitation is that the MDL and SQL are not indicative of sample-specific matrix limitations. The laboratory performing analytical work for the RSAP currently establishes the MDL/SQL for pesticides in sediment using sand for spiking and analysis. For organochlorine pesticides which adsorb to fine-grained particulates, the difference in recovery from sand and fine-grained silty sediments may be substantial. Lower recovery from actual samples will result in the derived MDL/SQL being biased low.

The decision to use or not use the SQL (or some fraction of the SQL) as an estimator of analyte concentration for non-detect results is not straightforward, and must balance the advantages and disadvantages of such an approach. As stated earlier, when the CRQL is substantially lower than the concentration of concern, there is no great advantage to using the SQL rather than half of the CRQL. For those analytes where the CRQL is substantially higher than the concentration of concern, there is also no good reason for using the SQL as an estimator because nothing is gained. Dieldrin and endrin in sediment are examples of such analytes. For analytes where the CRQL is similar to the concentration of concern, the use of the SQL as an estimator in determining background concentrations would be a conservative approach. The use of the SQL would normally yield a lower estimate for the background concentration. If the SQL was not also used as an estimator for non-detects in RI site data, the result would be to increase the likelihood of identifying an analyte as a

contaminant of concern in the risk assessment process. Rather than using the biased approach of the SQL as an estimator for non-detects with background data and half of CRQL for RI study site data, it may be better to simply use the standard approach of half the CRQL for all non-detects and then examine the data and the SQL levels during the risk assessment process as a semiquantitative aid in making recommendations and decisions. It should be noted that these options do not require modification of standard laboratory procedures, but simply thorough examination of complete laboratory CLP data packages.

There are also various statistically-based procedures which can be used to arrive at a less biased estimate of population parameters when the data set is censored. Some of these procedures would not be appropriate for use with some RSAP data sets which are expected to be highly censored (high percentage of non-detects). Other procedures, such as the method of maximum likelihood (Cohen, 1959 and 1961) may be of utility even with highly censored data. The use of such procedures as alternatives to using half the CRQL will be evaluated for both establishing background and in risk assessment for comparisons with background concentrations.

The RSAP project report, when prepared, will present a complete analysis and discussion of the implications of using various methods of handling non-detects. Where necessary, the reference background data may be summarized using different approaches to the handling of the censored data. This would leave open a range of options for use as appropriate in the risk assessment process.

3.2.7 Adequacy of Data

The reference data will be evaluated as it is collected to confirm that the data are adequate to meet the requirements of the risk assessment. There are two key aspects of data adequacy which must be considered. The first concerns the suitability of the reference locations to represent background conditions for APG. Because this first issue will be considered separately for each environmental media, it is discussed in following paragraphs which address each of these media. The second question to be considered is whether or not an adequate number of reference samples has been collected for each media population group. For example, if it is determined that Sassafra and Woodstown sandy loam soils form a population group, do the four samples collected for these soil series provide adequate estimates of population mean and variance?

In Section 3.1.5 of this workplan it was noted that the necessary number of reference samples and site samples to be collected and analyzed for a specific element/compound should be adequate to detect the relative difference between the background concentration and that concentration which represents an unacceptable risk. The number of necessary study site samples is dependent on the percent relative difference to be detected, the coefficient of variation of concentrations of the element/compound in the media being sampled, and the desired confidence and power of the statistical test (95% for each). A larger number of reference samples increases the accuracy of the estimate of the mean background concentration and reduces the estimate of population variance. When the relative percent difference to be detected is large, that is when there is a large percent difference between background concentrations and unacceptable concentrations, the number of samples collected for both reference and site characterization can be quite small. For those elements and compounds which have small percent differences between background concentrations and unacceptable concentrations, a reasonably low estimate of variance is necessary to avoid having to collect a prohibitively large number of study site samples. A better estimate of population mean and variance requires that a larger number of reference samples be collected. The following paragraphs in this workplan addressing the individual environmental media contain estimates of the anticipated background concentrations, concentrations protective of human health and the environment assuming conservative exposure scenarios, and associated percent relative differences.

3.3 FIELD RECONNAISSANCE

A preliminary reconnaissance was conducted at all potential sampling locations in order to confirm that the selected sites are appropriate reference locations and are representative of conditions at APG. Topography, land use patterns, surface water quality, sediment types, and vegetative communities were evaluated during this survey. In addition, the soil types at some locations have been evaluated during a preliminary reconnaissance. Soil types were selected based on soil surveys and will be field verified prior to the finalization of the soil sampling location. Prior to sampling, each location will be field-verified as needed. The data obtained from the visual inspection are being evaluated in consultation with APG, USGS, MDGS, BG&E, USEPA, and MDE personnel to confirm locations. The planned reference sampling locations for each environmental media are shown in Figures presented with the discussion for the particular media.

3.4 SOIL

3.4.1 General

The development and chemistry of soils is strongly influenced by several factors, including the nature of the parent material from which the soil is derived, climate, the mode of placement at a site, time, topography, vegetation cover, and soil organisms. In the coastal plain area on which APG is located, soils have been physically transported from the location of the parent rock materials from which the soils were formed. Therefore, element concentrations in coastal plain soils are expected to be different than in soils developed by chemical weathering over parent rock material. The parent crystalline rocks of the Piedmont Plateau are mostly deformed schist and gneiss of late Precambrian or Cambrian age.

Climate is the principal factor responsible for the development of soils into horizons since it also influences other important factors in the development and chemistry of soils, specifically soil organisms and vegetation cover. The general types of soil horizons are the uppermost organic (O) horizons containing large amounts of plant and animal residue, the eluvial (A) horizons from which minerals are leached, and the illuvial (B) horizons in which minerals are deposited. Beneath these horizons is the C horizon which is the original unweathered soil deposit. These typical soil horizons are described in Table 3-2.

Exposure to contaminated soil is through direct contact, ingestion, and respiration of soil particulates. Except for activities involving excavation, such as construction, human exposure is generally restricted to surface soils. Furthermore, much of the initial RI soil sampling efforts will emphasize sampling and analysis of surface soils. This does not imply that exposure will be to soil of the 'O' and 'A' horizons because erosion and human activities may have removed the uppermost soil horizons at a site.

3.4.2 Expected Analyte Concentrations

An approximate range of metals concentrations in Maryland soils is available from published literature (Shacklette and Boerngen, 1981 and 1984). These data are summarized in Table 3-3 along with conservative estimates of soil concentrations protective of human health assuming use of the land for residential purposes. Review of these data indicates that detection of small relative differences between background and study site concentrations for metals will be necessary for arsenic, beryllium, manganese and vanadium. The available data concerning the background concentrations of anthropogenic organic compounds in regional soils are much less extensive. Six surface soil samples were collected from the Gunpowder State Park to obtain background data for the O-Field RI. A

**Table 3-2
The Soil Profile**

HORIZON TYPES	HORIZONS	HORIZON DESCRIPTIONS
ORGANIC HORIZONS	O1	Organic horizon wherein the original forms of plant and animal residues can be recognized by the naked eye.
	O2	Organic horizon wherein the original plant and animal forms cannot be so distinguished.
ELUVIAL HORIZONS (mineral)	A1	Topmost mineral horizon, containing a strong admixture of humified organic matter which tends to impart a darker color than that of the lower horizons.
	A2	Horizon of maximum eluviation of clay, iron, and aluminum oxides and a corresponding concentration of resistant minerals, such as quartz, in sand and quartz sizes. Generally lighter in color than the A1 horizon.
	A3	Transition layer between A and B horizons with properties more nearly like those of A1 or A2 than of the underlying B. Sometimes absent.
ILLUVIAL HORIZONS (mineral)	B1	Transition layer between A and B horizons with properties more nearly like B than A. Sometimes absent.
	B2	Zone of maximum accumulation of clays and hydrous oxides. These may have moved down from upper horizons or may have formed in place. Organic matter content is generally higher than that of A2 horizon. Maximum development of blocky or prismatic structure or both.
	B3	Transition between B and C horizons with properties more like those of B.
	C	Unconsolidated material underlying the solum. Outside the zones of major biological activities and is little effected by the solum forming process.

Soil profile and horizon descriptions taken from Nyle C. Brady, "The Nature and Properties of Soils", 8th Edition, MacMillan, 1974.

<p align="center">Table 3-3 Estimated Range of Element Concentrations in Maryland Soils and Associated Risk-Based Concentrations (RBCs)</p>					
ELEMENT	RANGE^a (mg/kg)	MEAN (mg/kg)	STANDARD DEVIATION (mg/kg)	RESIDENTIAL RBCs (mg/kg)	RELATIVE DIFFERENCE
Antimony	<1.0 - 2.0	<1.0	---	31	31
Arsenic	1.1 - 7.1	3.8	2.7	0.37^b	0.1
Barium	150 - 700	393	184	5500	14
Beryllium^c	ND - 3.0	1.00	1.29	0.15^b	0.2
Cadmium ^{c,d}	ND - 4.0	--	--	39	--
Chromium	15 - 100	48	41	78,000	1625
Cobalt ^{c,e}	ND - 20	6.9	8.2	4700	680
Copper	5.0 - 70	20	23	2900	145
Lead	10 - 50	22	14	400 ^f	18
Manganese^d	<2.0 - 7000	640	---	390	0.6
Mercury	0.04 - 0.14	0.070	0.038	23	330
Nickel ^{c,g}	ND - 30	12	13	1600	133
Selenium ^h	<0.1 - 0.5	0.27	0.16	390	1440
Silver ^{c,i}	ND - 5.0	---	---	390	--
Vanadium	20 - 150	63	53	550	9
Zinc	8.0 - 113	39	38	23,000	590

NOTES: RBC data were obtained from USEPA Risk-Based Concentration Table, Third Quarter 1994. The carcinogenic criteria are for a risk level of 10^{-6} and the noncarcinogenic criteria are for a target hazard index of one (1.0). This table lists only those elements for which there are reference doses (RfDs) and/or slope factors available to calculate carcinogenic and noncarcinogenic toxicity criteria. Analytes shown in bold text are those where detection of a small relative difference will be necessary.

^aSoils are sampled from the zone of eluviation (B horizon).

^bCarcinogenic criteria.

^cNon-detectable concentrations (ND) are taken as zero in calculating the mean and standard deviation.

^dData are for Eastern USA soils.

^eConcentrations of "<3" ppm are taken as 3 ppm in calculating the mean and standard deviation.

^fThis value for lead is not a calculated RBC, but rather a screening value for human health.

^gConcentrations of "<5" ppm are taken as 5 ppm in calculating the mean and standard deviation.

^hConcentrations of "<0.1" ppm are taken as 0.1 ppm in calculating the mean and standard deviation.

ⁱData are from the conterminous USA.

-- No value calculated.

summary of those data along with criteria levels protective of human health assuming residential land usage is presented in Table 3-4.

3.4.3 Soil Types and Characteristics

The most recent soil survey of the land comprising APG was performed in 1927 (Perkins and Winant, 1927). Recent soil surveys of Harford and Baltimore Counties (1975 and 1976) do not address APG property, except for Carroll Island and Graces Quarters. The principal soil types on Graces Quarters are Mattapex silt loam, Matapeake silt loam, Sassafras sandy loam, Woodstown sandy loam, Tidal Marsh, and Alluvial Land. On Carroll Island, the principal soil types are Woodstown loam, Woodstown sandy loam, Fallsington loam, Sassafras sandy loam, Mattapex silt loam, Barclay silt loam, and tidal marsh. The soil classifications systems and nomenclature changed between the time of the 1927 and recent soil surveys. Review of all of the surveys indicates that the principal soil series which will be found in both the Aberdeen and Edgewood Areas of APG include the Sassafras, Keyport, and Elkton series, and Tidal Marsh.

The concentrations of elements and organic anthropogenic compounds in the soil are expected to be related to certain soil characteristics. The concentrations of metals are expected to be higher in soils with greater cation exchange capacity (CEC). The CEC of a soil is related to the grain size distribution, especially the percentage of clay present, and also to the mineralogy of the soil. These factors and greater amounts of organic matter in the soil may also result in higher concentrations of anthropogenic compounds in the surface soil due to greater adsorption, lesser leaching, and retention of the compounds in the surface soil.

3.4.4 Location and Number of Samples

Soil will be collected at 30 off-post sampling sites in Harford, Baltimore, and Cecil Counties. The proposed locations, soil types, and analytes are presented in Figure 3-2 and Table 3-5. Several factors must be considered when selecting proposed reference soil sampling locations.

The principal consideration is obtaining an adequate number of samples of each major soil type found on APG where study work is being performed. More than a dozen individual soil series are expected to be present on APG. If the soil chemistry of each of these soil series was completely independent of other soil series, then the planned 30 reference soil samples would very likely not be adequate for the initial phase of work. However, it is expected that element concentrations in many of these soils will be similar, and that these chemically similar soils will be found to be part of population groupings. If the number of soil population groups is small, then it is expected that the planned 30 samples will be adequate to provide an initial estimate of population characteristics which will allow determination of the number of additional samples which will be necessary during a second phase of reference soil sampling. It is anticipated that the planned 30 initial soil samples will provide for most elements and compounds all the data necessary to establish background concentrations for use in risk assessments. For selected elements, most likely including carcinogenic metals, a second supplemental phase of soil sampling will probably be necessary to adequately establish reference background concentrations. The concentrations of anthropogenic organic compounds in surface soil as a result of regional air transport are expected to be largely independent of soil series and more likely related to surface soil characteristics such as grain size and organic matter content. The planned 15 or 30 samples with analysis for these compounds are expected to provide adequate reference data.

Another major consideration is collection of the reference soil samples from a geographically broad portion of the nearby coastal plain area such that regional variations in element and especially air transported anthropogenic organic compounds are detected and appropriately considered. The

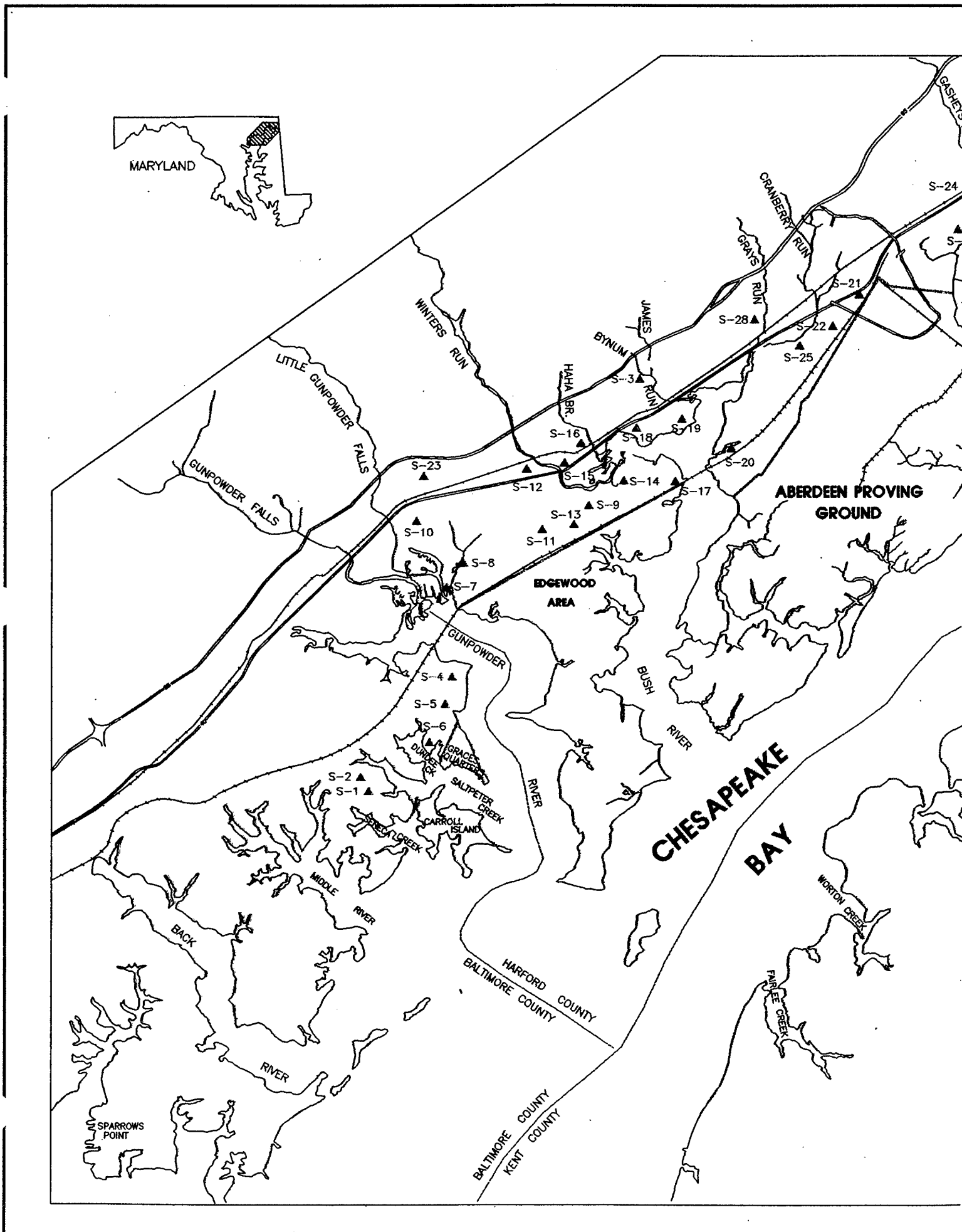
Table 3-4
Estimated Range of Anthropogenic Compounds in Regional Soils
and Associated Risk-Based Concentrations (RBCs) in mg/kg

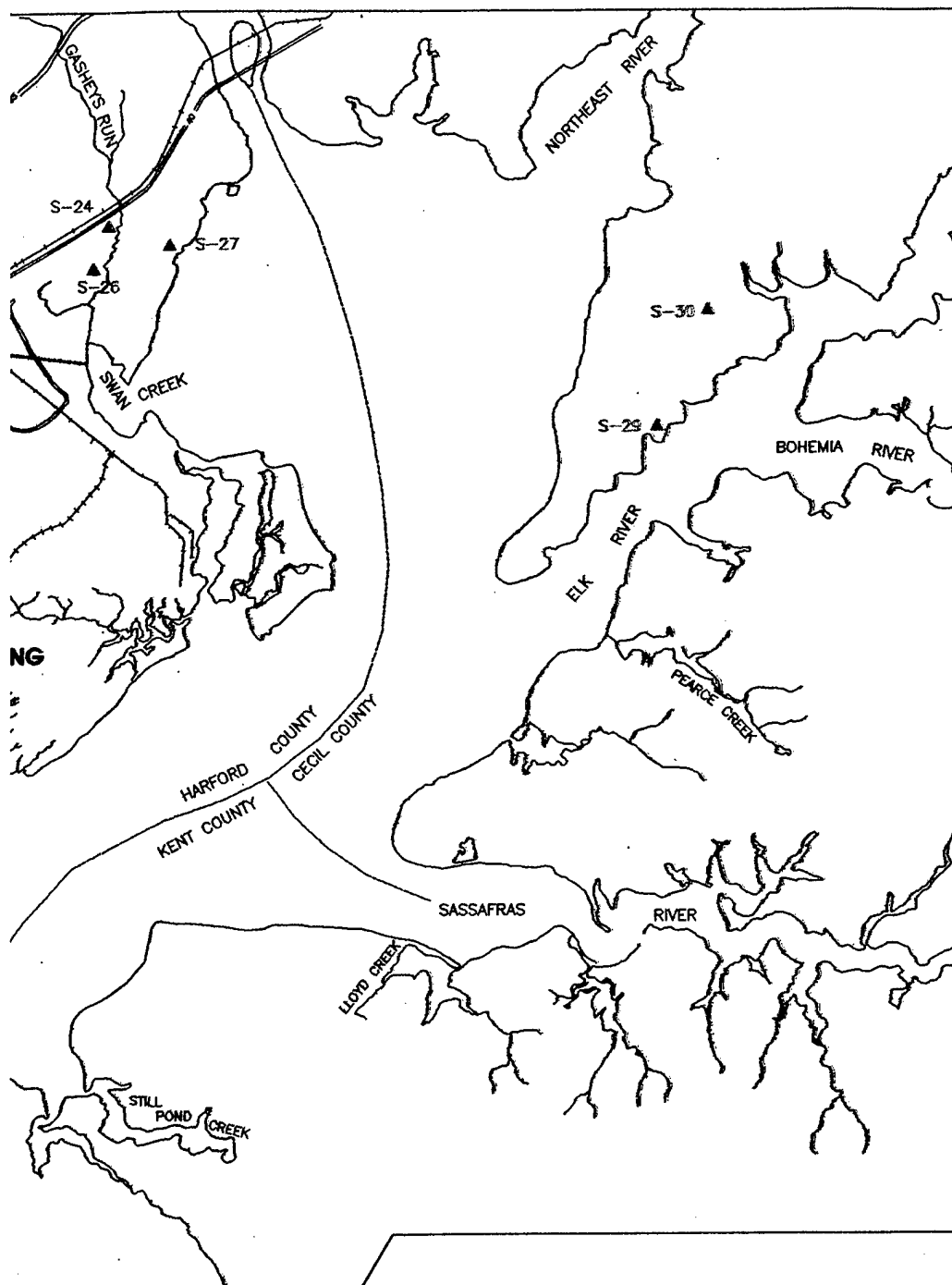
Analyte	Range	Mean	Sample std. dev.	Residential RBCs	Relative Difference
PCBs (Aroclor 1016)	<0.105	<0.105	---	5.5	52
PCBs (Aroclor 1260)	<0.2 - 0.26	0.127	0.065	0.083^a	0.7
4,4'-DDD	<0.021	<0.021	---	2.7 ^a	130
4,4'-DDE	<0.021	<0.021	---	1.9 ^a	90
4,4'-DDT	<0.021	<0.021	---	1.9 ^a	90
Dieldrin	<0.021	<0.021	---	0.04^a	2
Toxaphene	<0.21	<0.21	---	0.58^a	3
Methoxychlor	<0.105	<0.105	---	390	3700
alpha-BHC	<0.0105	<0.0105	---	0.1^a	10
beta-BHC	<0.0105	<0.0105	---	0.35 ^a	33
gamma-BHC	<0.0105	<0.0105	---	0.49 ^a	47
Endrin	<0.021	<0.021	---	23	1100
Aldrin	<0.0105	<0.0105	---	0.038^a	4
Chlordane	<0.105	<0.105	---	0.49^a	5
Heptachlor epoxide	<0.0105	<0.0105	---	0.07^a	7
Heptachlor	<0.0105	<0.0105	---	0.14 ^a	13
Benzo(a)pyrene	<0.870	<0.870	---	0.088^a	0.1
Naphthalene	<0.870	<0.870	---	3100	3560
Pyrene	<0.870	<0.870	---	2300	2640
Butyl benzyl phthalate	<0.870	<0.870	---	16,000	18400
Dimethyl phthalate	<0.870	<0.870	---	780,000	>>>
Di-N-butylphthalate	<0.870	<0.870	---	7800	9000
Di-N-octylphthalate	<0.870	<0.870	---	1600	1800
bis(2-ethylhexyl)phthalate	<0.870	<0.870	---	46 ^a	53

NOTES: RBC data were obtained from USEPA Risk-Based Concentration Table, Third Quarter, 1994. The carcinogenic criteria are for a risk level of 10^{-6} and the noncarcinogenic criteria are for a target hazard index of one (1.0). This table lists only those elements for which there are reference doses (RfDs) and/or slope factors available to calculate carcinogenic and noncarcinogenic toxicity criteria. Analytes shown in bold text are those where detection of a small relative difference will be necessary.

^aCarcinogenic criteria.

--- No value calculated.





LEGEND

- COUNTY LINE
- MAJOR ROAD
- INSTALLATION BOUNDARY
- + + RAILROAD TRACKS
- ▲ S-30 SOIL SAMPLING LOCATION

0 5000 FEET 0 1500 METERS

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DAAA15-91-D-0014

**ICF KAISER
ENGINEERS**

1301 Continental Drive
Suite 101
Abingdon, Maryland 21009
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PREPARED KDM

TASK NO: 05232

CHECKED DR

ICF DWG NO:

DATE 02-08-95

REFSAMP3

FIGURE 3-2
ABERDEEN PROVING GROUND

REFERENCE
SOIL
SAMPLING LOCATIONS

Table 3-5 Soil Sampling Locations and Chemical Analyses					
ICF KE Sample Number	Location	Soil Type	Analytes		
			TAL Inorganics	TCL Semivolatiles, Pesticides/PCBs	Hexavalent Chromium, Dioxins/Furans, Gross Alpha & Beta
S-1	BG&E Power Lines near pole number 1078	Sassafras sandy loam	•	•	
S-2	BG&E Power Lines near pole number 1074	Woodstown sandy loam	•	•	
S-3	Rt. 7 and Bush Rd.	Hatboro soils	•	•	•
S-4	Gunpowder Falls State Park	Tidal marsh	•	•	•
S-5	Gunpowder Falls State Park	Sassafras sandy loam	•	•	
S-6	Gunpowder Falls State Park	Woodstown sandy loam	•	•	•
S-7	Mariner Point Park	Matapeake silt loam	•	•	•
S-8	Robert Copenhaver Park	Alluvial land	•	•	
S-9	Edgewood Elementary School	Mattapex silt loam	•	•	•
S-10	Edelin Rd. & Trimble Rd.	Keyport silt loam	•	•	
S-11	Army covered reservoir	Beltsville silt loam	•	•	
S-12	Army Van Bibber Water Treatment Plant	Hatboro silt loam	•	•	
S-13	Edgewood Elementary School	Woodstown loam	•	•	•
S-14	Frey's Rd. & Willoughby Beach Rd.	Othello silt loam	•	•	•
S-15	South of RR tracks and west of Rt. 24	Loamy and Clayey land	•	•	•
S-16	Area between Continental Drive and Norris Rd.	Keyport silt loam	•	•	•

Table 3-5 continued Soil Sampling Locations and Chemical Analyses					
ICF KE Sample Number	Location	Soil Type	Analytes		
			TAL Inorganics	TCL Semivolatiles, Pesticides/PCBs	Hexavalent Chromium, Dioxins/Furans, Gross Alpha & Beta
S-17	Gum Point near MDGS Well 181	Delanco silt loam	•	•	•
S-18	Leight Park	Beltsville silt loam	•	•	
S-19	William Longley Park	Elkton silt loam	•	•	
S-20	Club House Rd. & Gulf Rd.	Elsinboro loam	•	•	•
S-21	North of Aberdeen Walmart on Rt.7	Matapeake silt	•	•	
S-22	Cranberry Run Business Park	Elsinboro loam	•	•	
S-23	East of Beavers Ct.	Keyport silt loam	•	•	
S-24	Johns Hopkins Property -- Gashey Creek Farm	Mattapex silt loam	•	•	•
S-25	Cranberry Road MDGS Well 197	Codorus silt loam	•	•	•
S-26	Johns Hopkins Property -- Gashey Creek Farm	Alluvial land	•	•	•
S-27	Johns Hopkins Property -- Gashey Creek Farm	Matapeake silt loam	•	•	
S-28	Rt. 7 near Joe's Auto Body	Sassafras silty loam	•	•	
S-29	Elk Neck State Park	Tidal marsh	•	•	
S-30	Elk Neck State Park	Keyport silt loam	•	•	•
TOTALS			30	30	15

distribution of reference soil sampling locations from northeastern Baltimore County northeastward into Cecil County provides this geographically broad distribution.

The third major consideration in selecting reference soil sampling locations is avoidance of sites possibly contaminated by local pollution sources, such as nearby incinerators or sludge disposal operations.

3.4.5 Sampling and Analysis Approach

The initial investigation at each proposed reference sampling location will involve examination of the soil to a depth of at least three feet using shovels and hand augers. The field log for each site will be completed to record observations concerning site topography, vegetation, other pertinent observations, and for each soil horizon the primary and secondary constituents, including approximate grain size and sorting; color (using a Munsell color chart); plasticity; and moisture content. If field observations indicate that the soil survey maps are not accurate and the soil type at the site is not as anticipated, a new location will be selected in the same general area.

After a sampling site has been confirmed as suitable, surface soil samples will be collected from the uppermost soil horizon immediately beneath the vegetation mat to a depth which will not exceed 6 inches. It is anticipated that either the O2, A1, or A2 horizon will be sampled when the soil has not been subject to disturbance by human activity or significant erosion. Field observations of soil grain size, organic matter content, color, and plasticity will be used in an attempt to sample only one soil horizon. Surface soil from all sampling sites will be collected for analysis to determine soil characteristics (grain size distribution, plasticity, organic carbon content, pH, moisture content, USCS classification) and concentrations of TAL inorganics, TCL semivolatiles, and TCL pesticides/PCBs. Surface soil samples from one half of the sites will be collected for analysis to determine levels of gross alpha, gross beta, hexavalent chromium, and dioxins/furans.

If the surface soil sample is collected from the "O" or "A" horizons, a second sample will be collected at the site from a greater depth in the "B" horizon. This second sample at the site will be collected for analysis to determine TAL metals concentrations and soil characteristics. The purpose of this second sample at each site is to determine if element concentrations are significantly higher in the illuvial "B" horizon and to better represent background soils for APG study areas where soils have been recently disturbed (within last 10 or 20 years) and surface soils present are not the original "O" or "A" horizons. Analysis of these "B" horizon samples for anthropogenic organic compounds will not be performed because these compounds which have been transported by air are expected to have been deposited across APG primarily during the years since the soils at the study sites have been disturbed and are expected to be present in surface soils, with the particular soil horizon being present at the surface normally not a factor in determining concentration.

3.4.6 Evaluation of Aberdeen Proving Ground Soils

Reference soils must be representative of APG study site soils for the reference data to be useful in risk assessments. This can only be known if it is determined that the soil series and/or soil characteristics for reference soils are similar to those of APG study site soils.

APG soils from selected study sites will be evaluated and compared to reference soils. The two principal objectives of this work are to:

- Verify that the reference soil types are the same as those that exist at on-post study sites, and
- Verify that the range and distribution of soil physical characteristics at on-post study sites are adequately represented by the reference sampling program.

It is believed that the wide range of off-post soil types being sampled during the RSAP for chemical analysis encompasses all of the soil types found at APG on-post study sites. However, the on-post efforts may suggest that some soil types are not present on-post and that other soil types should be sampled more extensively. It is likely that surface soils at APG are predominantly silt loams and as such are primarily clayey silt and sandy silt.

The field and laboratory work which will be performed to accomplish the above stated objectives includes: (1) examination of study soils using shovels and hand augers to verify or determine the soil types present and the characteristics of the soils, and (2) physical testing of selected study site soil samples to verify field observations of soil characteristics. The study areas which will be addressed by field and laboratory work will include the Lauderick Creek area, the Canal Creek and Kings Creek drainage areas, the Westwood area, O-Field, D-Field, M-Field, J-Field, Carroll Island, Graces Quarters, and the Phillips Army Airfield Fire Training Area.

Portions of APG, especially the range areas, are geographically distant from off-post air emissions sources of anthropogenic compounds. Therefore, the concentrations of these compounds in APG soils may be less than in soils along the coastal plain corridor where the reference soil samples will be collected. For example, the concentrations of lead in the reference soil samples may be higher than those in soils at downrange study sites because of the proximity of the reference sampling sites to major highways. To address this consideration, remedial investigation data for various sites will be evaluated. If the remedial investigation data are not adequate for this purpose, approximately six surface soil samples will be collected from APG areas expected to be free of contamination. The analysis of these samples, if necessary, will be for the complete range of parameters to be determined for reference soil samples.

A portion of the surface soil sampling at RI/FS study sites will be in drainage ditches where transport of contaminants is suspected. The soils in these ditches will have undergone some degree of sorting by the transport process, and it is anticipated that natural element concentrations in finer-grained sorted soils will be higher than in other coarser-grained deposits in the sampled drainageways. For such situations the composite chemistry of reference soils is not alone adequate to use in comparison to study site soil samples. This data requirement will be addressed by selecting approximately six reference soil samples (of six soil types) and analyzing separately for TAL inorganics that portion of the sample which is silt and clay (passing a No. 200 sieve). These data will allow determination of appropriate background element concentrations in surface soil samples from RI/FS study sites which have been sorted by surface water transport.

3.5 SURFACE WATER

3.5.1 General

The chemistry of surface water is primarily determined by: (1) the chemistry of soils in the watershed area, (2) the release of anthropogenic materials from point and non-point sources in the watershed, and (3) the type of surface water body and location of the sampling point within the system.

Surface water from the Chesapeake Bay and the types of streams found on APG is not used as a source of drinking water. Therefore, any direct exposure of humans to surface water contaminants will be primarily through recreational activities such as swimming. Another human exposure pathway is consumption of fish, crabs, and other aquatic organisms. The protection of aquatic life will likely be the primary factor in risk assessment which determines acceptable levels of contaminants in surface water.

3.5.2 Surface Water Types and Characteristics

Regional surface waters in Baltimore County, Harford County, and Cecil County on the Eastern Shore include both freshwater and estuarine systems and consist of rivers, estuarine creeks, freshwater creeks, estuarine marshes, freshwater marshes, freshwater ponds, and ephemeral ponds. Flow and volume in major rivers of the region ranges widely.

The salinity in the estuarine systems surrounding APG ranges from fresh water to approximately 5 ppt and varies seasonally. On the Eastern Shore conditions are slightly more saline due to the Coriolis effect. Based on limited studies, the estuarine rivers surrounding APG show little stratification (Magnien et al. in prep.).

Surface water element concentrations are in part determined by the chemistry of soils in the drainage basin. Therefore, the relative portions of a freshwater drainage basin which lie above the fall line in the Piedmont and below in the Coastal Plain may affect freshwater stream chemistry because of the possible differences in soil chemistry.

All surface water samples for metals are analyzed without filtering prior to analysis. Because metals are strongly adsorbed by clay, it is anticipated that samples of surface water with relatively high amounts of total suspended solids (TSS) will have much higher concentrations of some metals than other samples with low TSS levels. The RSAP surface water data for metals will be evaluated to identify those metals which will be present in turbid samples in association with suspended solids as well as dissolved solids. Care will be taken to ensure that procedures are established to prevent comparison of RI study site data with low TSS to reference surface water data with high TSS and associated high metals concentrations.

3.5.3 Expected Analyte Concentrations

The anticipated ranges of concentrations of elements in surface waters are presented in Table 3-6. This table also presents surface water quality criteria for these elements. Comparison of the anticipated concentrations of elements in surface water with the water quality criteria indicates that the percent relative differences are small for nearly all metals. Furthermore, for all metals except the carcinogens arsenic and beryllium, the ambient water quality criteria are much lower than criteria for protection of human health.

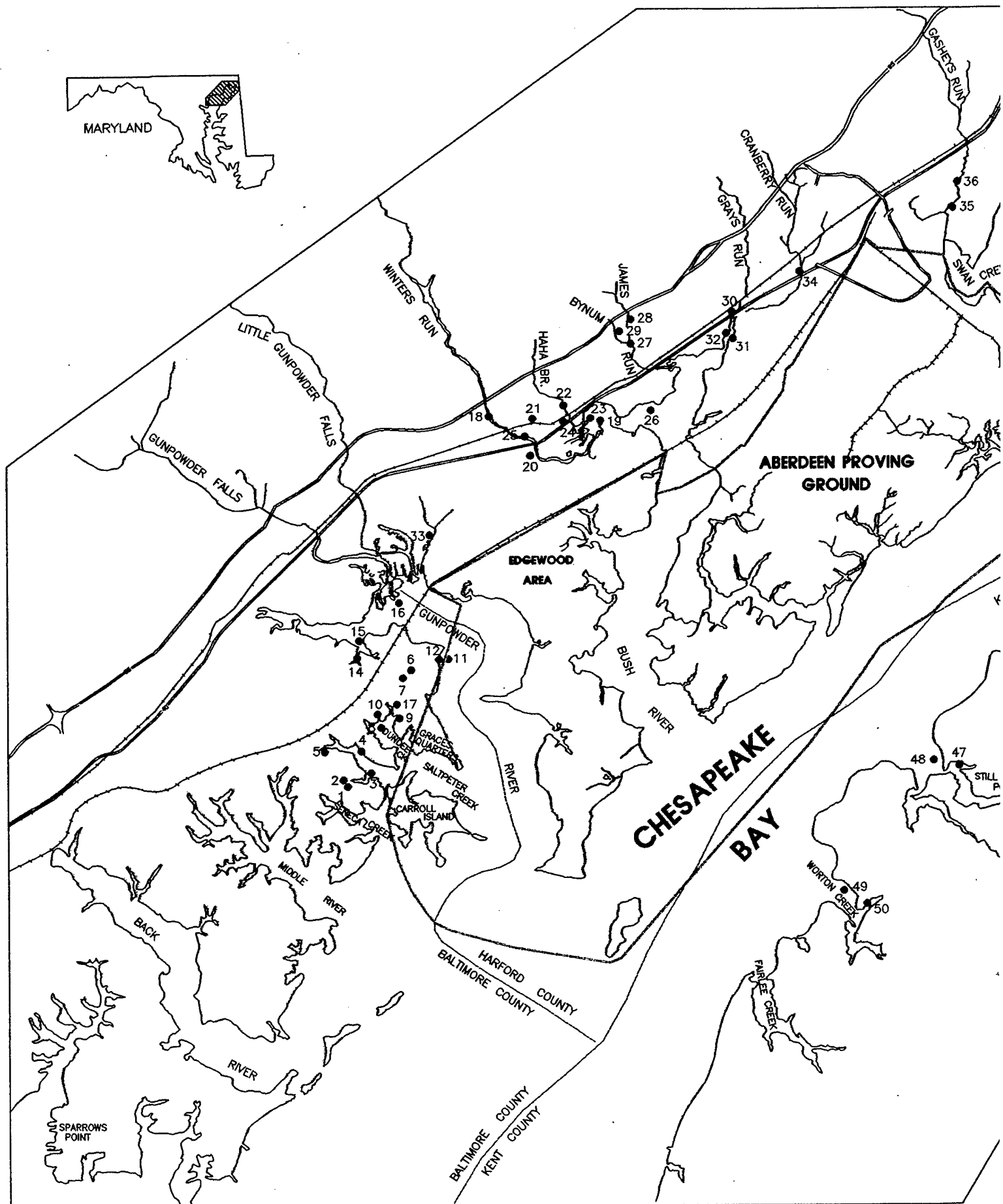
3.5.4 Location and Number of Samples

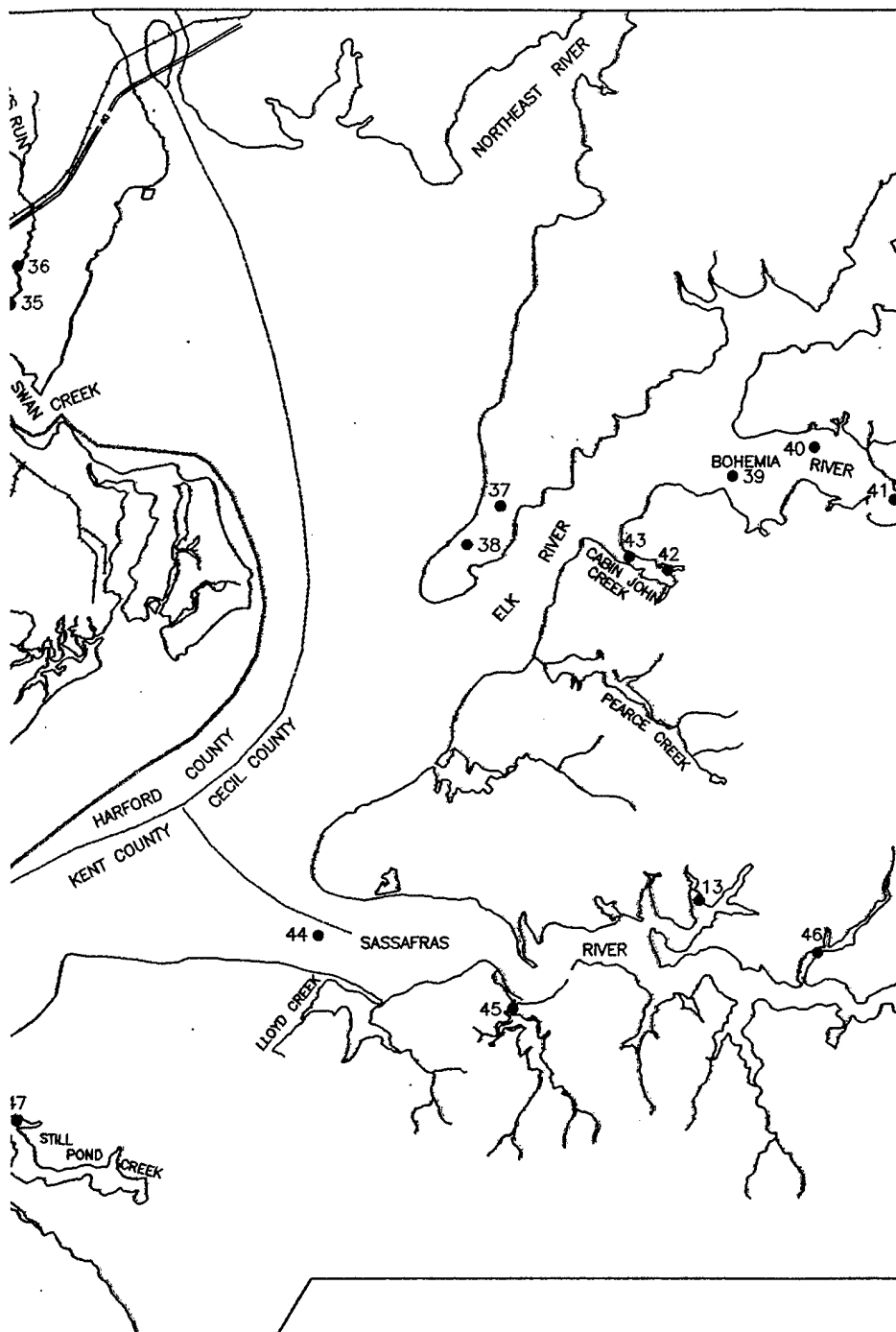
A total of 50 surface water samples will be collected from the region. The samples will be collected twice (in spring and fall) in order to assess seasonal variability. The surface water sampling locations are shown in Figure 3-3 and are described in Table 3-7. Locations have been selected to represent similar salinity, flow regimes, and bottom lithologies to the surface water bodies located on-site or downgradient of APG. Freshwater samples will be collected from various areas in Harford County and Baltimore County in areas receiving minimal industrial and agricultural runoff. These areas include ponds along the BG&E power lines, the upper reaches of Saltpeter and Dundee Creeks, Otter Point Creek, Gasheys Run, Bush River Natural Resources Area, and others. Care has been taken to avoid any known source areas of contamination within the watersheds which will be sampled. Due to the prevalence of industrial influences in the lower portions of Baltimore and Harford Counties, estuarine surface water samples also will be collected from Sassafra River, Worton Creek, Cabin John Creek, and the Bohemia River on the Eastern Shore in order to provide enough sampling locations to yield reference samples. Another goal was to select the reference surface water locations with drainage basin characteristics such as soil type that are similar to drainage basins of APG streams. This goal was somewhat limited by the necessity of sampling upgradient of potential

Table 3-6 Estimated Regional Surface Water Quality and Concentrations Protective of Human Health and Aquatic Life					
ELEMENT	RANGE (mg/L)	MEAN (mg/L)	HUMAN HEALTH CRITERIA (mg/L)	CHRONIC FRESHWATER AMBIENT WATER QUALITY CRITERIA (mg/L)	RELATIVE DIFFERENCE
Aluminum	0.05 - 5.9	1.2	---	0.087	0
Antimony	<0.050	0.025	1.85	0.030	0
Arsenic	<0.002 - 0.0035	<0.002	0.006	0.190	1
Barium	0.008 - 0.061	0.028	324	---	>5000
Beryllium	<0.005	<0.005	0.0025	0.0053	0
Cadmium	<0.005	<0.005	2.31	0.0011	2
Chromium	<0.005 - 0.0084	<0.005	23.1	0.011	0
Copper	<0.005 - 0.010	<0.005	---	0.012	0
Iron	0.26 - 27	2.5	---	1.0	0
Lead	<0.0015 - 0.016	0.0018	---	0.003	1
Magnesium	1.0 - 14	6.7	---	---	---
Manganese	0.026 - 122	3.1	23.1	---	7
Mercury	<0.0002	<0.0002	1.39	0.000012	0
Nickel	<0.010 - 0.024	<0.010	92.6	0.158	6
Selenium	<0.0125	<0.0025	23.1	0.005	1
Silver	<0.005	<0.005	23.1	0.00012	0
Thallium	<0.0125	<0.0125	0.231	0.040	3
Vanadium	<0.005 - 0.014	0.0054	32.4	---	>2300
Zinc	<0.005 - 0.078	0.016	1390	0.106	0

NOTES: The screening criteria were calculated using RAGS Part B methodology and input parameters. A very conservative scenario of swimming 92 days/year with 0.2 L/day water ingestion is assumed. The carcinogenic criteria are for a risk level of 10^{-6} and the noncarcinogenic criteria are for a target hazard index of one (1.0). This table lists only those elements for which there are reference doses (RfDs) and/or slope factors available to calculate carcinogenic and noncarcinogenic toxicity criteria. Analytes shown in bold text are those where detection of a small relative difference will be necessary.
 --- No value has been calculated.

sources of contamination. Some surface water sampling locations were selected along streams upgradient of the Route 40 commercial corridor to avoid potential contaminated runoff, but also have drainage basins almost completely in the Piedmont region. The larger surface water bodies surrounding APG receive much of their flow from Piedmont area runoff and data from these sampling





LEGEND

- COUNTY LINE
- MAJOR ROAD
- INSTALLATION BOUNDARY
- + + RAILROAD TRACKS
- 44 SURFACE WATER AND SEDIMENT SAMPLING LOCATION

0 5000 FEET

0 1500 METERS

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DAAA15-91-D-0014

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TASK NO: 05232

CHECKED DR

ICF DWG NO:

DATE 02-08-95

REFSAMP3

FIGURE 3-3

ABERDEEN PROVING GROUND

REFERENCE
SURFACE WATER
AND SEDIMENT
SAMPLING LOCATIONS

TABLE 3-7 SURFACE WATER SAMPLING LOCATIONS AND CHEMICAL ANALYSES				
SAMPLE NUMBER	TYPE OF SURFACE WATER BODY	LOCATION	ANALYTES	
			TAL INORGANICS	SELECT WATER QUALITY PARAMETERS
SW-1	Ephemeral Pond	BG&E power lines near pole #1079	•	•
SW-2	Freshwater Marsh	Saltpeter Creek near BG&E pole #1080	•	•
SW-3	Estuarine Creek	Saltpeter Creek	•	•
SW-4	Estuarine Marsh	Saltpeter Creek	•	•
SW-5	Freshwater Creek	Saltpeter Creek near BG&E pole #1050	•	•
SW-6	Freshwater Marsh	Dundee Creek headwaters at Gunpowder Falls State Park	•	•
SW-7	Freshwater Creek	Dundee Creek headwaters at Gunpowder Falls State Park	•	•
SW-8	Estuarine Creek	Dundee Creek	•	•
SW-9	Estuarine Marsh	Dundee Creek	•	•
SW-10	Freshwater Creek	Gunpowder Falls State Park Hammerman Area	•	•
SW-11	Estuarine Creek	North of Gunpowder River	•	•
SW-12	Estuarine Marsh	North of Gunpowder River	•	•
SW-13	Estuarine Creek	Back Creek on Sassafras River	•	•
SW-14	Estuarine Marsh	Railroad Creek of Gunpowder River	•	•
SW-15	Estuarine Creek	Railroad Creek of Gunpowder River	•	•
SW-16	Estuarine River	Gunpowder River headwaters	•	•
SW-17	Freshwater Pond	Gunpowder Falls State Park near Dundee Marina	•	•
SW-18	Freshwater Creek	Winters Run	•	•
SW-19	Estuarine Creek	Bush River Headwaters	•	•
SW-20	Freshwater Marsh	Otterpoint Creek	•	•
SW-21	Freshwater Pond	BG&E power lines near pole #2337	•	•
SW-22	Freshwater Creek	Haha Branch at BG&E power lines	•	•
SW-23	Freshwater Marsh	Haha Branch at BG&E power lines	•	•
SW-24	Estuarine Marsh	Otterpoint Creek	•	•
SW-25	Estuarine Creek	Otterpoint Creek	•	•
SW-26	Estuarine River	Bush River headwaters	•	•
SW-27	Freshwater Creek	James Run	•	•
SW-28	Freshwater Marsh	James Run	•	•

TABLE 3-7 CONTINUED SURFACE WATER SAMPLING LOCATIONS AND CHEMICAL ANALYSES				
SAMPLE NUMBER	TYPE OF SURFACE WATER BODY	LOCATION	ANALYTES	
			TAL INORGANICS	SELECT WATER QUALITY PARAMETERS
SW-29	Ephemeral Pond	Bush River Natural Resources Area	•	•
SW-30	Freshwater Pond	Pond along Route 40	•	•
SW-31	Estuarine Marsh	Church Creek	•	•
SW-32	Estuarine Creek	Church Creek	•	•
SW-33	Freshwater Marsh	Fosters Run	•	•
SW-34	Freshwater Creek	Cranberry Run	•	•
SW-35	Freshwater Marsh	Gasheys Creek	•	•
SW-36	Freshwater Creek	Gasheys Creek	•	•
SW-37	Freshwater Pond	Elk Neck State Park	•	•
SW-38	Ephemeral Pond	Elk Neck State Park	•	•
SW-39	Estuarine River	Bohemia River Mouth	•	•
SW-40	Estuarine River	Bohemia River - Battery Point	•	•
SW-41	Estuarine River	Bohemia River - Scotchman Creek	•	•
SW-42	Estuarine Marsh	Cabin John	•	•
SW-43	Estuarine Creek	Cabin John	•	•
SW-44	Estuarine River	Sassafras River mouth	•	•
SW-45	Estuarine River	Sassafras River - near Turner Creek	•	•
SW-46	Estuarine River	Sassafras River - Beachwood Glen	•	•
SW-47	Estuarine Marsh	Stillpond Creek	•	•
SW-48	Estuarine Creek	Stillpond Creek	•	•
SW-49	Estuarine Creek	Worton Creek	•	•
SW-50	Estuarine Marsh	Worton Creek	•	•
ALTERNATE LOCATIONS				
--	Freshwater Pond	Reservoir behind Joppa School	•	•
--	Ephemeral Pond	Van Bibber Treatment Plant	•	•
--	Freshwater Creek	Grays Run	•	•
--	Freshwater Marsh	Grays Run	•	•
--	Estuarine Creek	Lloyds Creek	•	•
--	Estuarine Marsh	Lloyds Creek	•	•
--	Estuarine River	Elk River	•	•
TOTALS			50	50

^aSurface water samples will be analyzed for alkalinity, hardness, TDS, TSS, and COD.

locations will provide a more complete understanding of natural surface water quality. The actual use of data from these locations in determining reference background conditions will be carefully evaluated.

3.5.5 Sampling and Analysis Approach

All surface water samples will be analyzed for TAL inorganics and selected water quality analytes (alkalinity, hardness, chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS)). Surface water samples will not be filtered prior to analysis.

Anthropogenic organic compounds are also commonly found in surface waters of the Chesapeake Bay and the streams which discharge to the Bay (Helz and Huggett, 1987). Examples of such compounds include phthalates and atrazine. The reference sampling and analysis program will not include analysis of surface water for such compounds because:

- The presence of these compounds in surface water is temporal in nature and therefore upgradient concentrations (local background) must be determined during RI sampling events. Some of these compounds, such as atrazine, will be present only seasonally.
- Local as well as regional sources may contribute to the presence of these contaminants in surface water. This will also contribute to the variable nature of contamination of surface water by anthropogenic compounds.

Because of the variable nature of anthropogenic contamination in surface water, the reference program is limited in its ability to provide complete background data for use in risk assessments. Because of this temporal nature of surface water contamination, local upgradient data adequate to support the risk assessment process must be collected as part of all RI surface water sampling efforts.

3.5.6 Evaluation of Aberdeen Proving Ground Surface Waters

The RSAP surface water sampling locations have been selected to represent the range of drainage basins, salinity, flow regimes, and bottom lithologies found on APG. The surface water chemical data collected as part of the RSAP will be evaluated along with the data for soils and sediments to verify the suitability of RSAP sampling locations and data for representing APG area background conditions.

3.6 SEDIMENT

3.6.1 General

The chemistry of sediments which are not contaminated by anthropogenic compounds will be largely determined by the nature of the soils in the drainage basin from which the sediments originated. Anthropogenic contaminants in sediments are transported from sources and deposited in regionally broad areas by both surface water and air.

3.6.2 Sediment Types and Characteristics

The grain size and organic matter content of sediments are expected to be the major characteristics of sediments which, along with location, determine concentrations of elements and anthropogenic contaminants in sediments. Naturally occurring and anthropogenic metals are associated primarily with fine grained sediments, principally clays. Anthropogenic organic compounds

of concern which will be addressed by the RSAP all have low water solubilities and are adsorbed to organic matter and fine-grained sediment particles. The grain size distribution and organic matter content of sediments are largely determined by flow regime, with easily transported organic matter and fine-grained material being found in areas of low transport energy (low flow velocity).

3.6.3 Expected Analyte Concentrations

Estimated concentrations of metals in sediment which could represent an unacceptable risk to the environment are presented in Table 3-8 (see discussion in Section 3.1.3). The elements for which detection of relatively small percent differences between background concentrations and levels protective of the environment is necessary include antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.

Table 3-8 Estimated Regional Sediment Element Concentrations and Levels Protective of Aquatic Life				
ELEMENT	RANGE (mg/kg)	MEAN (mg/kg)	BIOLOGICAL EFFECTS GUIDELINES (mg/kg)	RELATIVE DIFFERENCE
Antimony	<1.0 - 2.0	<1.0	2	2.0
Arsenic	1.1 - 7.1	3.8	8.2	2.2
Cadmium	<0.01 - 0.56	0.31	1.2	3.9
Chromium	15 - 100	48	81	1.7
Copper	5.0 - 70	20	34	1.7
Lead	10 - 50	22	46.7	2.1
Mercury	0.04 - 0.14	0.070	0.15	2.1
Nickel	ND - 30	12	20.9	1.7
Silver	ND - 5	---	1	---
Zinc	8 - 113	39	150	3.8

NOTES: The biological effects guidelines are the "Effects Range-Low (ER-L)" values reported by Long et al. (1993) except for antimony which was reported by Long and Morgan (1990). Analytes shown in bold text are those where detection of a small relative difference will be necessary.

— No value has been calculated.

Data concerning the concentrations of anthropogenic organic compounds in the sediments of the upper Chesapeake Bay and its tributary streams and rivers are very limited. Table 3-9 summarizes preliminary laboratory data from four locations at which sediment samples were recently taken as part of the Gunpowder River study. These locations were Seneca Creek, Saltpeter Creek, the Gunpowder River above the Edgewood Area of APG, and the lower end of the Gunpowder River estuary west-southwest of J-Field. The only RSAP analytes which were detected in these samples were very low

Table 3-9 Anticipated Anthropogenic Compounds in Sediment				
ANALYTE	RANGE (ug/kg)	MEAN (ug/kg)	BIOLOGICAL EFFECTS GUIDELINES (ug/kg)	RELATIVE DIFFERENCE
PCBs (Aroclor 1016)	<77.3	--	22.7	0
PCBs (Aroclor 1260)	<77.3	--	22.7	0
4,4'-DDD	<77.3	--	2	0
4,4'-DDE	<77.3	--	2.2	0
4,4'-DDT	<77.3	--	1	0
Dieldrin	<77.3	--	0.02	0
Toxaphene	<387	--	--	--
Methoxychlor	<38.7	--	--	--
alpha-BHC	<3.87	--	--	--
beta-BHC	<3.87	--	--	--
gamma-BHC	<3.87	--	--	--
Endrin	<3.87	--	0.02	0
Aldrin	<3.87	--	--	--
Chlordane	<3.87 - 3.58	2.05	0.5	0
Heptachlor epoxide	<3.87	--	--	--
Heptachlor	<3.87	--	--	--
Benzo(a)pyrene	<770	--	430	0
Naphthalene	<770	--	160	0
Pyrene	<770	--	665	0
Butylbenzylphthalate	<770	--	--	--
Dimethylphthalate	<770	--	--	--
Di-N-butylphthalate	<770	--	--	--
Di-N-octylphthalate	<770	--	--	--
bis(2-ethylhexyl)phthalate	<770 - 52	380	--	--

NOTES: The biological effects criteria are the "Effects Range-Low (ER-L)" values reported by Long and Morgan (1990) and updated where possible by Long et al. (1993). Analytes shown in bold text are those where detection of a small relative difference will be necessary.

-- No values have been calculated.

levels of chlordane and bis(2-ethylhexyl)phthalate in individual samples. Table 3-9 also presents screening guidelines published by NOAA (Long and Morgan 1990) and Long et al. (1993) which indicate the potential for adverse biological effects. Review of the table indicates that the ER-L values listed as biological effects criteria are lower than the routine CLP detection limits for various PCBs, pesticides, and PAHs.

3.6.4 Location and Number of Samples

A total of 50 sediment samples will be collected from the region. The sediment sampling locations are the same as those for surface water and are shown in Figure 3-3 and are described in Table 3-10. The locations have been selected to represent similar bottom lithologies to the surface water bodies located on-site or downgradient of APG. Care has been taken to avoid any known source areas of contamination within the watersheds which will be sampled. The selected sites were also chosen to avoid the immediate vicinity of possible sources of dioxins/furans (e.g. incinerators or burn areas). Due to the prevalence of industrial influences in the lower portions of Baltimore and Harford Counties, sediment samples also will be collected from Sassafras River, Worton Creek, Cabin John Creek, and the Bohemia River on the Eastern Shore in order to provide enough sampling locations to yield reference samples. As discussed for surface waters, another goal was to select the reference sampling locations with drainage basin characteristics, such as soil type, similar to drainage basins of APG streams. This goal was somewhat limited by the necessity of sampling upgradient of potential sources of contamination. Some sediment and surface water sampling locations were selected along streams upgradient of the Route 40 commercial corridor to avoid potential contaminated runoff, but these locations have drainage basins almost completely in the Piedmont region. The larger surface water bodies surrounding APG receive much of their flow and sediment deposits from Piedmont area runoff and data from these sampling locations will provide a more complete understanding of regional sediment chemistry. As for surface water, the actual use of data from these locations in determining reference background conditions will be carefully evaluated.

3.6.5 Sampling and Analysis Approach

The RSAP sediment samples will be collected using an Ekman grab sampler and samples will be representative of the topmost 6-inches. The field log for each site will be completed to record observations concerning site location, date and time, water depth and flow conditions such as tide or stream stage, aquatic vegetation, and sediment. The sediment description will include grain size and sorting, organic matter content, color (Munsell soil color), and plasticity.

All RSAP sediment samples will be analyzed for TCL PAHs, phthalates, pesticides and PCBs, and TAL inorganics. In addition, 50 percent of the samples will be analyzed for dioxins/furans and radioactive isotopes (gross alpha and gross beta). The analytical parameters for each sediment sample are listed in Table 3-10.

In addition to the chemical analyses, all sediment samples will be sent to a laboratory for physical testing (including USCS classification, percent moisture, organic matter content, Atterberg Limits, and grain size distribution) using American Society of Testing and Materials (ASTM) Methods outlined in the QAPjP.

3.6.6 Evaluation of APG Sediments

The RSAP sediment sampling locations have been selected to represent the range of drainage basins and bottom lithologies found on APG. The sediment chemical data collected as part of the RSAP will be evaluated along with the data for soils and surface water to verify the suitability of RSAP

Table 3-10 Sediment Sampling Locations and Chemical Analyses					
Sample Number	Location	Analytes			
		TAL Inorganics	TCL PAHs Phthalates Pest/PCBs	Dioxins Furans	Gross Alpha and Beta
Sed-1	BG&E Power Lines near pole #1079	•	•	•	•
Sed-2	Saltpeter Creek on BG&E Power lines near pole #1080	•	•		
Sed-3	Saltpeter Creek	•	•	•	•
Sed-4	Saltpeter Creek	•	•	•	•
Sed-5	Saltpeter Creek on BG&E Power lines near pole #1050	•	•	•	•
Sed-6	Dundee Creek headwaters at Gunpowder Falls State Park	•	•		
Sed-7	Dundee Creek headwaters at Gunpowder Falls State Park	•	•		
Sed-8	Dundee Creek	•	•		
Sed-9	Dundee Creek	•	•		
Sed-10	Gunpowder Falls State Park Hammerman Area	•	•	•	•
Sed-11	North of Gunpowder River	•	•	•	•
Sed-12	North of Gunpowder River	•	•	•	•
Sed-13	Back Creek on Sassafras River	•	•	•	•
Sed-14	Railroad Creek of Gunpowder River	•	•		
Sed-15	Railroad Creek of Gunpowder River	•	•		
Sed-16	Gunpowder River Headwaters	•	•	•	•
Sed-17	Gunpowder Falls State Park near Dundee Marina	•	•		
Sed-18	Winters Run	•	•	•	•
Sed-19	Otterpoint Creek	•	•		
Sed-20	Otterpoint Creek	•	•	•	•
Sed-21	BG&E Power Lines near pole #2337	•	•		
Sed-22	Haha Branch	•	•	•	•
Sed-23	Haha Branch	•	•		
Sed-24	Otterpoint Creek	•	•		
Sed-25	Otterpoint Creek	•	•		
Sed-26	Bush River Headwaters	•	•	•	•
Sed-27	James Run	•	•		

Table 3-10 continued
Sediment Sampling Locations and Chemical Analyses

Sample Number	Location	Analytes			
		TAL Inorganics	TCL PAHs Phthalates Pest/PCBs	Dioxins Furans	Gross Alpha and Beta
Sed-28	James Run	•	•		
Sed-29	Bush River Natural Resources Area	•	•		
Sed-30	Pond along Rt. 40	•	•		
Sed-31	Church Creek	•	•		
Sed-32	Church Creek	•	•		
Sed-33	Fosters Run	•	•	•	•
Sed-34	Cranberry Run	•	•	•	•
Sed-35	Gasheys Creek	•	•	•	•
Sed-36	Gasheys Creek	•	•	•	•
Sed-37	Elk Neck State Park	•	•		
Sed-38	Elk Neck State Park	•	•	•	•
Sed-39	Bohemia River Mouth	•	•		
Sed-40	Bohemia River--Battery Point	•	•		
Sed-41	Bohemia River--Scotchman Creek	•	•		
Sed-42	Cabin John	•	•	•	•
Sed-43	Cabin John	•	•		
Sed-44	Sassafras River Mouth	•	•	•	•
Sed-45	Sassafras River--Near Turner Creek	•	•	•	•
Sed-46	Sassafras River--Beachwood Glen	•	•		
Sed-47	Stillpond Creek	•	•	•	•
Sed-48	Stillpond Creek	•	•	•	•
Sed-49	Worton Creek	•	•	•	•
Sed-50	Worton Creek	•	•	•	•
ALTERNATE LOCATIONS ARE THE SAME AS FOR SURFACE WATER					
TOTALS		50	50	50	25

sampling locations and data for representing APG area background conditions. Information concerning sediments and soils from the RI studies will also be evaluated to verify suitability.

3.7 BIOLOGICAL/ECOLOGICAL SURVEYS

A benthic community survey of reference locations will be conducted to gain a better understanding of the expected fauna present in the estuarine sediments of APG. This benthic community survey is necessary to support ecological risk assessments at APG.

To effectively complement the RSAP using the benthic community, 20 locations will be sampled, many of which overlap sediment chemistry locations. Samples will be taken in the spring and summer to account for temporal variability. Many organisms exhibit a larger recruitment in the spring and a reduction in abundance during the summer (Holland et al. 1977; Mountford et al. 1977; Holland et al. 1980; Holland 1985; Ranasinghe et al. 1992). These locations will be analyzed for several parameters (e.g., abundance and biomass diversity) recommended in the Chesapeake Bay Benthic Restoration Goals (Ranasinghe et al. 1993).

At all locations, sediment samples will be divided vertically into two fractions, 0-5 cm deep and > 5 cm deep. Analysis of each sample fraction will include identification of organisms to the lowest taxonomic level possible (species preferred) and a measure of biomass. Grain size distribution will be analyzed on sediments from each sample location. Water quality parameters that will be measured include temperature, salinity, conductivity, dissolved oxygen, percent saturation of dissolved oxygen, redox potential, and pH.

4.0 FIELD AND LABORATORY PROCEDURES

This portion of the FOWP describes the procedures which will be used during this program for soil sampling, surface water sampling, sediment sampling, health and safety, sample shipment and chain of custody, equipment decontamination, physical and chemical analysis of environmental samples, data management, and disposal of investigation derived wastes. All procedures summarized in the FOWP are consistent with APG/WES developed SOPs. The SOPs have been designed to meet EPA, Federal and State technical requirements. All SOPs can be found in the Quality Assurance Project Plan which is a companion document to the FOWP.

4.1 SOIL SAMPLING

The collection of surface soil at each reference sampling site will begin with site investigation and selection to verify that the soil type in the area is that which is intended to be sampled. Soil survey maps and visual examination of possible sampling sites will first be accomplished to select an area in which surface soils do not appear to have been disturbed or possibly contaminated by human activities. The soils within the selected area will then be inspected through the use of shovels and hand augers to verify that the site soil matches the description of the target soil type. The hand augering to verify soil type in the selected reference sampling area will normally be accomplished to a depth of at least 3 feet.

Samples will be collected from the uppermost soil horizon immediately beneath the vegetation mat to a depth which will not exceed 6 inches. It is anticipated that either the O2, A1, or A2 horizon will be sampled when the soil has not been subject to disturbance by human activity or significant erosion. Field observations of soil grain size, organic matter content, color, and plasticity will be used in an attempt to sample only one soil horizon.

A complete description of the soil profile to a depth of 3 feet and of soil samples collected will be entered into the field logbook. At a minimum, the following observations and soil characteristics will be noted:

- Primary and secondary constituents, including approximate grain size and sorting;
- Color (Munsell soil color);
- Plasticity;
- Moisture content;
- Odors;
- Obvious signs of biota; and
- Site topography, vegetation, and any other pertinent observations.

Soil samples for chemical analysis and physical testing will be collected using decontaminated stainless steel hand tools and pans. Tools which will be used include hand augers, scoops, and spatulas. A quantity of soil adequate to fill all sample containers will be placed into a stainless steel pan where it will be mixed using the "coning and quartering method" to ensure homogeneity prior to placement into sample containers. A small amount of soil will be placed into a jar and the headspace will be monitored for organic vapors using a photoionization detector (PID).

The soil will be homogenized in the tray using a decontaminated stainless steel scoop. The homogenized soil sample will then be placed into the appropriate sample jars, sealed, and placed in a cooler maintained at 4° C. All sampling equipment will be decontaminated before further sampling, and soils remaining in the tray will be replaced in the area disturbed by sampling. Finally, the vegetative mat will be replaced over the disturbed areas. The locations of each surface soil sample will be marked with a stake, and located with Global Positioning System (GPS).

4.2 SURFACE WATER SAMPLING

Sampling will be performed by a two-person team from a flat-bottomed boat, wide-hulled canoe, or by wading. The sampling site location will be determined and marked on a known scale map using a compass and at least two permanent visual markers (i.e., a tower) and determined with GPS. In addition, photographs will be taken in the direction of each visual marker from the sample site. This will facilitate locating the sample location for any subsequent sampling events. Samples will be taken during an ebbing tide for consistency between samples and to enable comparison with sampling during RI/FS work at APG, which is expected to often be performed during ebbing tide.

Sampling procedures are defined in the QAPJP. These procedures are as follows:

- An initial volume of water will be collected to measure pH, conductivity, temperature, salinity, dissolved oxygen, and redox potential with the HYDROLAB™. The values will be recorded and the water discarded.
- The sample bottles will be filled with surface water using the following technique:
 1. After removing the cap from the bottle, and triple rinsing, hold the bottle upside down and immerse it several inches below the water's surface. Slowly turn the bottle upright allowing the air to be released gently and the bottle to fill up.
 2. Remove the bottle from the water and add the proper preservatives, if required.
- After the sample container has been sealed, the outside of the bottle will be rinsed with clean water, dried, labeled and chain-of custody sealed.
- The bottle will be placed in a sealable plastic bag and immediately cooled to 4°C in a cooler. Sample packaging and shipment procedures are discussed in Section 4.7.

4.3 SEDIMENT SAMPLING

Sediment samples will be taken from a boat or floating platform using an Ekman grab sampler. The sediment sample contained within the grab sampler will be placed in a stainless steel bowl and homogenized using a stainless steel spoon and the "coning and quartering method". The following field measurements will be made: headspace PID reading, temperature, and pH. A complete description of the sample will be entered into the field logbook. At a minimum, the following characteristics will be noted:

- Primary and secondary constituents, including approximate grain size and sorting;
- Color (Munsell soil color); and

- Any other pertinent observations.

The appropriate sample jars will then be filled with sediment and sealed. The sediment sampling will be accomplished concurrently with and at the same locations as the fall surface water sampling event. The sampling locations will be determined and documented as described for surface water sampling. Field personnel handling sediment samples and sample containers prior to sealing will wear gloves which have been decontaminated by washing with a non-phosphate detergent solution and rinsing with deionized⁴ water to minimize the possibility of introducing phthalates into the samples.

4.4 SAMPLE SHIPMENT AND CHAIN OF CUSTODY

Samples will be labeled and preserved in the field, as described in the QAPjP. Each sample bottle will be sealed in a plastic bag. Samples will be packed in plastic ice chests with sufficient ice to maintain $4 \pm 2^{\circ}\text{C}$ during transport to the laboratory. The ice will be double-bagged to prevent contact of the melt water with the samples. Custody seals will be affixed to all coolers before shipment. All samples will be checked for integrity and lid closure to prevent leakage.

Sample coolers will be labeled for shipment to the laboratory for next day delivery. The laboratory will be notified of the sample shipment and the estimated arrival time of the samples being delivered. Any broken sample bottles or loosened sample jar lids at the time of laboratory receipt will be reported to the Sampling Team Leader so that additional sampling may be conducted.

Chain-of-Custody and Field Parameter forms identifying all the sampling containers, chemical analysis requirements, and other field data required by the laboratory will be completed for each sample cooler and shipped to the laboratory in each cooler. The procedure for filling out these forms is provided in the SOPs found in the QAPjP. These forms will be completed, signed by the sample team members, and shipped to the laboratory inside each cooler. Upon arrival at the laboratory, the designated laboratory personnel will open the cooler, inspect, record the condition of each sampling container, and sign the chain-of-custody form.

4.5 EQUIPMENT DECONTAMINATION

All sampling equipment and tools will be decontaminated prior to use at a sampling site. All equipment used to obtain an environmental sample (hand augers, trowels, gloves when sediment sampling, etc.) will be cleaned using the following procedures:

- brush with unchlorinated water and non-phosphate laboratory detergent such as Liquinox;
- rinse with unchlorinated water;
- rinse with 10 percent reagent-grade nitric acid;
- rinse with deionized⁵ water;
- rinse with reagent grade isopropanol;

⁴The water used has been analyzed and determined to be free of phthalates and other analytes.

⁵The water used has been analyzed and determined to be free of analytes.

- rinse with deionized water;
- allow to air dry; and
- wrap in aluminum foil (shiny side out).

4.6 PHYSICAL AND CHEMICAL ANALYSIS OF ENVIRONMENTAL SAMPLES

Soil and sediment samples will be analyzed for both chemical and physical parameters. Surface water samples will be analyzed for chemical constituents only. Chemical analysis will be conducted by ESE Laboratory in Gainesville, Florida, and physical analysis will be conducted by ICF KE in Pittsburgh or Special Testing Laboratories of Raleigh, NC. Analytes of concern include PAHs, pesticides, PCBs, metals, dioxins/furans, and radioactive isotopes. Analytical method descriptions and laboratory detection or quantitation limits are provided in the QAPjP (ICF KE 1995). All holding times that are given in the QAPjP will be observed and samples will be processed in the lab in the time allotted.

4.6.1 Physical Analysis of Soil and Sediment

All physical analyses of soil and sediment samples will be performed in accordance with ASTM methods by either the ICF KE geotechnical laboratory in Pittsburgh or Special Testing Laboratories of Raleigh, NC. Grain size distribution, Atterberg Limits, USCS classification, organic matter content, and percent moisture will be determined. These methods are discussed further in the QAPjP. A sample for physical analyses will be collected from every sediment and soil sampling location.

4.6.2 Semivolatile Organic Compounds

TCL PAHs, TCL pesticides, TCL PCBs, and TCL phthalates will be analyzed in accordance with USEPA CLP methods. Semi-volatile organic compounds will be analyzed by gas chromatography/mass spectroscopy. Pesticides and PCBs will be analyzed using gas chromatography electron capture detection. These methods are described further in the QAPjP. All sediment samples will be analyzed for these semivolatile organic compounds. Soil samples will be analyzed for all of these semivolatiles except phthalates.

4.6.3 Inorganic Analytes

Inorganic analytes will be analyzed in accordance with USEPA CLP methods. Mercury will be analyzed using cold vapor atomic absorption spectroscopy. Arsenic, selenium, lead and thallium are commonly analyzed using graphite furnace atomic absorption spectroscopy (GFAA), and that procedure will be used for the RSAP. In addition, antimony and beryllium in soil/sediment and antimony, beryllium, cadmium, and silver will be analyzed in surface water using GFAA to provide lower detection limits than the more commonly used ICP procedure for these metals. The remaining TAL metals will be analyzed using inductively coupled plasma techniques. These methods are described further in the QAPjP. Concentrations of TAL inorganics will be determined in all samples from all media.

4.6.4 Radioactive Isotopes

Gross alpha and gross beta emitters will be analyzed in accordance with USEPA approved procedures. Gross alpha and gross beta scans will be conducted using gas flow proportional counting. These methods are described further in the QAPjP. Gross alpha and gross beta emitters will be analyzed for in 50 percent of all surface soil and sediment samples.

4.6.5 Dioxins/Furans

Dioxins and furans will be analyzed using USEPA CLP methods. The method uses high-resolution capillary column chromatography and low-resolution mass spectrometry requiring a matrix-specific extraction, and analyte-specific clean-up. These methods are described further in the QAPjP. Dioxins and furans will be analyzed for in 50 percent of all surface soil and sediment samples.

4.6.6 Selected Water Quality Analytes

Alkalinity will be determined by EPA titrimetric methods. Hardness will be determined by inorganic analysis according to the Standard Methods for the Examination of Water and Wastewater. Chemical oxygen demand will be determined by oxidation/reduction using EPA methods. TDS and TSS will be analyzed according to USEPA methods by filtration through a glass filter. All methods are described in greater detail in the QAPjP. These selected water chemistry analytes will be analyzed for in 100 percent of surface water samples.

4.6.7 Quality Assurance and Quality Control

The RSAP will include the collection of several types of quality control samples. These samples will include duplicates and rinse blanks/equipment blanks. This section describes the method of collection and frequency of field quality control blanks. Numbers of quality control samples are presented in Table 4-1.

Duplicate samples will be collected at 10 percent of all field sampling locations. Fractions for the same analytical parameters will always be collected consecutively.

Rinse blanks will be collected when the sampling equipment is decontaminated and reused in the field or when a sample collection vessel (bailer or beaker) will be used, at a frequency of 1 per 20 samples (5 percent of total). The equipment used in sampling will be rinsed with blank water (HPLC-grade for organics, deionized for inorganics) and the water running off the equipment will be collected in sample containers.

Samples will be collected to be as representative of the matrix as practicable. Extreme care will be used to avoid the potential for contamination during the sampling event using the appropriate USEPA and/or USAEC decontamination procedures (see Section 9). Procedures described in this section are designed to eliminate external contamination through the use of good sampling techniques. SOPs for sampling activities are provided in Appendix A of the QAPjP.

4.7 DATA MANAGEMENT

The Installation Restoration Data Management System (IRDMS) is an integrated system for the collection, validation, storage, retrieval, and presentation of USAEC Installation Restoration Program (IRP) and base closure data. IRDMS PCTool provides the ability to enter chemical, geotechnical, and map file data. Each contractor is supplied with the appropriate microcomputer-based software to allow for record entry, error checking, and quality control for chemical, geotechnical, and map file data. Records accepted by the local error checking program are then transmitted through a Bulletin Board System (BBS) AT&T Model 3B2 minicomputer, which is centrally located at USAEC's Edgewood, MD facility. Subsequent processing at the central site (duplicate error check) results in an elevation of the accepted records to a higher file "level" and the eventual updating of installation-specific data bases in a Pyramid system.

Table 4-1 Summary of Field and Quality Assurance Samples					
MEDIA		Soil ^a	Surface ^b Water	Sediment	Total ^a
Number of Samples		57	50	50	157
QA Samples	Duplicates	6	5	5	16
	Rinse Blanks	2		3	5
Analytes	TAL Inorganics	57 ^c	50	50	157
	TCL Pest/PCBs	36		50	86
	TCL PAHs/Phthalates	36		50	86
	Dioxins/Furans	21		25	46
	Gross Alpha & Beta	21		25	46
	Water Qual Analytes		50		50

^a Assumes that on-post RI data does not provide adequate regional on-post anthropogenic data and that six samples are collected for that purpose.

^b Number of samples shown is for each sampling event. Two sampling events are planned for surface water.

^c Assumes that half (15) of the soil sampling sites will have a second sample collected from the "B" horizon for metals analysis.

4.7.1 Organization

There are three levels of data recognized in the IRDMS. Level 1 consists of all files on the ICF KE microcomputer that have been entered or generated by the error checking program. The only Level 1 files that are present on the Pyramid system are program files. Program files are composed of several elements. An element may contain various contractor-written utilities or programs, add-streams, or other commonly used sets of commands.

It is anticipated that error-free files will be transmitted on a weekly basis to the Pyramid system. The ICF KE terminal is linked to the network using software supplied by USAEC and a Hayes modem. Terminal usage logs will be established and maintained as a permanent record of communications. If communications cannot be established and maintained, ICF KE will seek optional means, where needed, for forwarding the data to USAEC. To verify acceptance, each file will be processed through an error checking program that is identical to the one on ICF KE's microcomputer. Accepted files will then be sent to the Pyramid system. Should any files fail this final error check, ICF KE will be notified and required to correct detected errors and retransmit the data.

Upon arrival at the Pyramid system, the files will be classified as Level 2 files. These records will be protected by write keys and, therefore, they may not be modified by ICF KE. They may be read by ICF KE, provided the appropriate read key is specified. All Level 2 files will be the responsibility of USAEC. Level 2 files will exist only until the data are loaded into the appropriate installation data base; normally within 10 working days.

Data in the installation data base are considered Level 3 data. They may be accessed by ICF KE using USAEC-supplied report programs and the appropriate read key; however, they are protected from changes by a write key. The installation data bases are the responsibility of the U.S. Army.

While in the process of collecting, documenting, packaging, and shipping samples to the laboratory, the field sampling team will transfer sample data from their notebooks to field parameter forms. Once the samples arrive at the laboratory, this information will be used to create Level 1 data files by laboratory or ICF KE in the IRDMS. Status information (e.g., date sampled, date received, data extraction/analysis due) will form a part of the record.

Each step in the analytical process will result in updates to the data files. The operation performed (e.g., preparation, extraction, analysis, data review, data package prepared), the data obtained, and the date that each step was completed will be entered into the system and made available for status checks. The laboratory will validate the data, perform error-checking and correction using the USAEC routines, and transmit the Level 1 files to USAEC, via the 3COM communications network. Hard-copy documentation will also be transferred from the laboratory to USAEC. For non-USAEC methodologies, all data files will be input by the ICF KE PDC and transmitted to USAEC.

Once the Level 1 files have been processed at USAEC, the PDC will transmit any required corrections, then generate a backup tape copy. This step will be completed within 50 days after the samples have been collected. The laboratory and ICF KE will archive copies of all analytical data and supporting documentation. Records will also be maintained, so that historical summaries of all analyses may be generated by site, by client, or by sample type. Refer to Figure 4-1 for a summary diagram of how these data will be handled.

4.7.2 Project Data

Data for entry into the IRDMS and generated during this project will consist of geotechnical data and sampling/analytical data. The types, origin, IRDMS files, and handling of these data are described below.

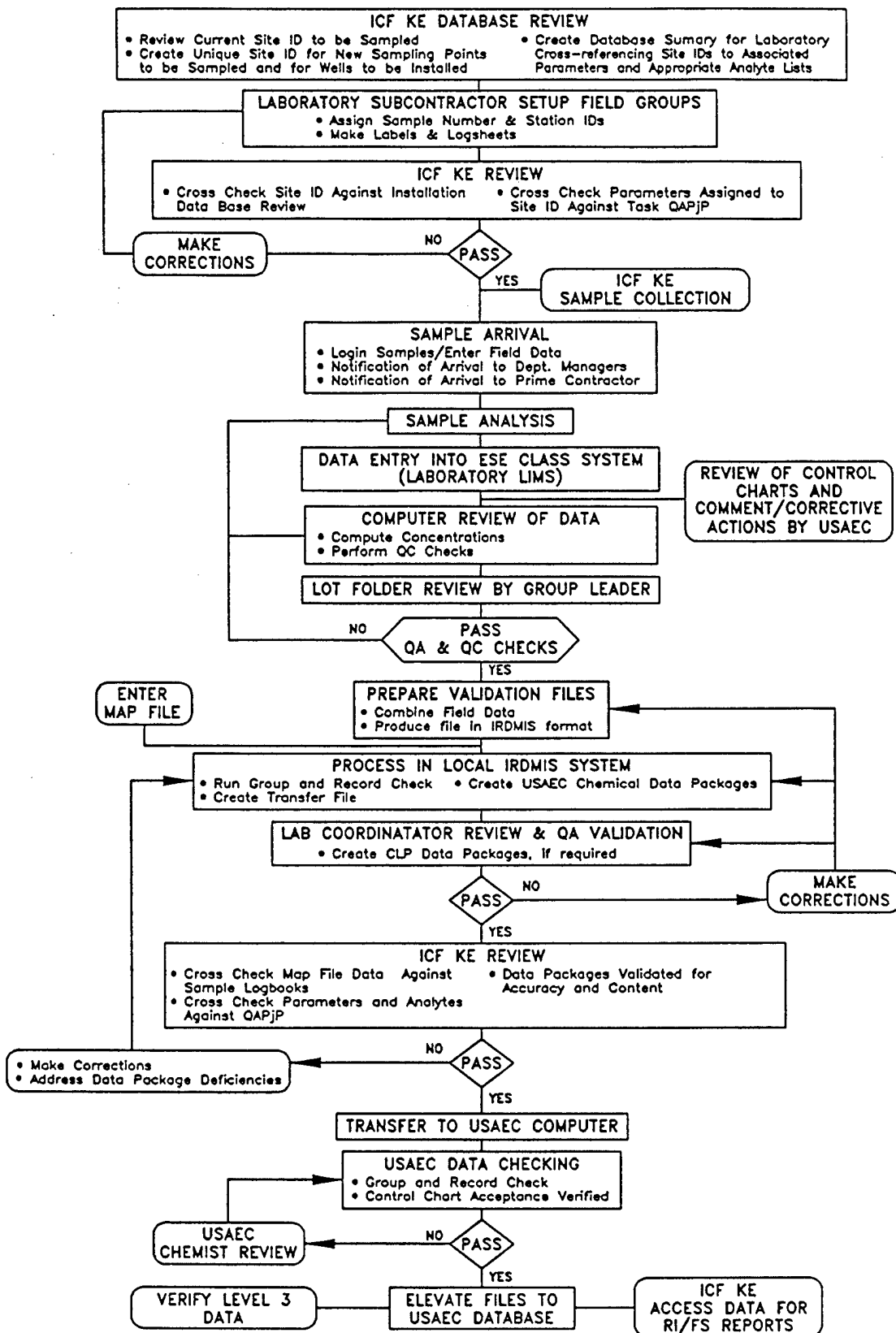
A map file is a listing of sample sites and corresponding north and east coordinates. Map files must be created prior to entry of any other type of sample site data into the IRDMS. A map file data form will be prepared from data contained in the field sampling logbooks based on GPS data. These data are entered into the computer by the PDC, and a computer printout of the file is checked and corrected by the ICF KE Field Operations Leader. The data are submitted to USAEC in Level 1. Once validated, this map file is elevated to Level 2. This must take place before any other data are processed.

4.7.3 Sampling and Analytical Data

Data from analyses performed by the laboratory are input into various chemical data files, including CSW (surface water), CSE (sediment), and CQC (QC data). Data from sampling activities that are required for data entry into IRDMS will be documented by the sampling team on Field Parameter Forms (FPFs) (see QAPjP for sample). FPFs will be sent to the laboratory for all analyses. A description of sampling and analytical data generation and manipulation is provided below.

Sampling data will be collected in the field in a permanently bound notebook (log). Portions of the information will be transferred to a three-part FPF. This information will include the site type, site ID, sampling date and time, field sample number, sample depth (if applicable), and the sampling

FIGURE 4-1 DATA MANAGEMENT FLOW CHART U.S. ARMY ENVIRONMENTAL CENTER



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technique. A complete list of required information is presented in Table 4-2. In addition, each sample container will be annotated in waterproof ink with the installation name, sample number, sampling date, analytes, and preservatives. A chain-of-custody form will also be completed in the field and will accompany the samples to the laboratory, along with the FPF.

Collection of analytical data will begin when samples arrive at the laboratory. A laboratory technician will first verify that the samples noted on the chain-of-custody form coincide with the sample containers being delivered. If any containers are broken or missing, the chain-of-custody form will be annotated and the ICF KE QA Coordinator will be notified immediately. Samples will then be logged into a project-specific notebook and the computerized laboratory data management system according to parameter code, site ID, and laboratory sample number. The FPFs and chain-of-custody forms will then be submitted to a laboratory data technician for later correlation with the analytical results.

Upon receipt of the sample log information, the laboratory Quality Assurance Coordinator (QAC) will assign analytical lot numbers to all samples. The first three letters of the six-character sample code will designate the analytical lot, while the remaining three digits will indicate the sample number within the lot (e.g., AAB006 indicates the sixth sample in lot AAB). All quality control samples required for each analytical lot (e.g., method blank, control spike at two times the certified reporting limit (CRL), and two control spikes at ten times the CRL) will also receive USAEC sample numbers. The data technician will enter the sample information into the IRDMS to generate partially-completed data coding forms.

When the samples are taken from storage for analysis, the chain-of-custody (COC) form will be signed by the Data Analyst to acknowledge receipt of the samples for processing. When analyses are complete, the Data Analyst will reduce the data for QC samples to determine if the analyses were in control. The QC results will then be reviewed by the Laboratory Section Manager and forwarded to the QAC for verification. If the QAC agrees that the data are in control, the Data Analyst will be directed to proceed with data reduction for the samples. Concentrations of contaminants in extracts will be determined from instrumental responses of the extracts applied to the instrument calibration curve. The resultant concentration will then be modified by applying the appropriate dilution/concentration and sample weight or volume to obtain a final reportable concentration in the original matrix. For sediments, results will not be corrected for moisture; however, percent moisture is reported with the analytical results. Aqueous results will be reported in units of micrograms per liter and solid samples will be reported in micrograms per gram.

The data will contain no more than three significant digits and will be rounded to the appropriate number of significant digits, based on certification class and dilution, only after all calculations have been completed. When samples are diluted into a certified range, the reported concentration will contain one less significant digit than an undiluted sample. Values less than the

Table 4-2
List of Sampling Data

- Installation
- Field Sample Number
- Matrix
- Sample Depth (if applicable)
- Sample Time and Date
- Sample Location
- Sampling Method
- Analytes
- Preservatives
- Significant Observations
- Printed Name and Signature of Sampler
- Number of Samples Taken
- Water Quality Parameters
- Number of Shipping Containers
- Date of Shipment

reporting limit will be reported as "less than". If a sample is diluted below the reporting limit, the value will be reported as "less than" the reporting limit multiplied by the dilution factor to more accurately reflect the observable limit. The dilution factor will be reported with the data. Method blank values will not normally be subtracted from sample results submitted to USAEC. However, all data will be reviewed by the ICF KE QA Coordinator.

When data reduction has been completed for the samples, all data (whether on magnetic media or hard-copy) will be transmitted to USAEC. The correlation of the analytical and field data will be performed by Potomac Research Incorporated (PRI). Table 4-3 lists the information that is required for IRDMS.

4.8 DISPOSAL OF INVESTIGATION DERIVED WASTES

Since the objective of this task is to establish baseline reference data in areas not impacted by APG activities and other potential sources of contamination (if known), the wastes derived from this program are not believed to be hazardous. Investigation-derived waste from this project includes: used decontamination water, disposable sampling equipment, and solid waste such as cardboard boxes, paper, etc. The proposed procedures for disposing of each of these wastes is discussed below.

4.8.1 Decontamination Water

Given the objectives of this task and the sampling locations, the decontamination water is not believed to be hazardous. The waste water will be discharged into the Army Waste Water Treatment Plant (WWTP). Prior to discharge, the water will be contained and transported to a secured central location on APG property (O-Field or former salvage yard on G-Street). In order to confirm that containerized water meets all required pre-treatment standards, a sample will be collected prior to disposal and analyzed for the list of analytes required by 40 CFR part 433 subpart A, for metal finishing point sources as required by the APG WWTP.

4.8.2 Solid Waste and Disposable Sampling Equipment

All disposable sampling equipment and solid waste will be sealed in plastic bags and cardboard drums and disposed in dumpsters at APG. Every effort will be made to minimize the volume of this material.

Table 4-3 IRDMS Required Information

IRDMS Data Entry Element	Geotech Data Entry	Chem Data Entry	IRDMS Data Entry Element	Geotech Data Entry	Chem Data Entry
Action or Measurement	x		Laboratory Analysis Number		x
Analysis Accuracy/Variation		x	Lot		x
Analysis Date		x	Measurement Boolean		x
Aquifer Name	x	x	Measurement Date and Time	x	
Base Closure Indicator	x	x	Method Number (geotech)	x	
Bore Date	x		Moisture		x
CAS Registry Number		x	Number of Coordinate Pairs	---	---
Class Indicator		x	Organization	x	x
Coordinate Pair Number	x	x	Pointer Site Type	x	x
Coordinate System Code	x	x	Pointer Site Identification	x	x
Coordinate Accuracy Code	x	x	Prime Contractor	x	x
Data Qualifier		x	QC Type		---
Delivery Order Indicator		x	QC Spike		x
Delivery Order Number		x	QC Test Code		x
Depth (geotechnical)	x		Record Identification		x
Depth Unit	---	---	Sample Program		x
Depth (chemical)		x	Sample Technique		x
Description	x	x	Sample Number		x
Dilution Factor		x	Sample Date		x
Elevation Accuracy Code	x	x	Sample Preparation Date		x
Entry	x		Site Type	x	x
Field Sample Number		x	Site Identification	x	x
File Sequence Number		x	Surface Elevation	x	x
File (Media) Type	x	x	Test Name (Analyte)		x
File Identification	x		Test Name (Analyte) Code		x
Flag/Qualifier Long Desc		x	Test Classification		x
Flag or Qualifier		x	Uncorrected Value		x
Flag/Qualifier Short Desc		x	Unit of Measurement	x	x
Flagging Code		x	Value (chemical)		x
Initials	x	x	Value (geotechnical)	x	
Installation Code	x	x	Well Construction Date	x	
Interval Thickness	x		X Coordinate	x	x
Laboratory		x	Y Coordinate	x	x

5.0 PROJECT IMPLEMENTATION

5.1 SCHEDULE

Approval for surface water and sediment sampling and analysis was obtained after review of the draft FOWP by U.S. Army and Regulatory organizations, and that sampling has been completed. During the review of the draft final workplan, permission from off-post property owners was obtained for soil sampling. Soil sampling was accomplished during April and May of 1994. Any necessary supplemental sampling of soil, surface water, or sediment will be accomplished after analysis of Phase 1 data. A draft interim report which presents all results for Phase 1 sampling and analysis of surface water, sediment, and soil will be completed by March 1995. A draft final interim report will be submitted after any supplemental sampling and analysis is performed, and after review and revision of the draft interim report. A draft final report will be submitted after all sampling and analysis data are available.

5.2 HEALTH AND SAFETY

All field activities will be conducted in accordance with the approved Risk and Biological Impact Assessment Health and Safety Plan (ICF KE 1992), and the task-specific Health and Safety Plan Addendum. There are only minimal task-specific health and safety concerns about chemical hazards since every effort will be made to minimize the potential of encountering chemical hazards and field samples will be screened using a photoionization detector (PID). Every effort will be made to locate and identify hazards (especially physical hazards or weather-related hazards) prior to commencing field activities, and these hazards will be appropriately minimized. Coordination, notification, emergency response contacts, and telephone numbers are given in Table 5-1.

The sampling logistics include obtaining written permission to access all sampling sites from the U.S. Army and each property owner prior to the commencement of field operations. All efforts will be made to minimize the impact of field operations at all sampling areas. All areas disturbed during sampling procedures will be restored to original conditions.

Table 5-1 Key Individuals for the RSAP			
NAME	TITLE	ADDRESS	PHONE NUMBER
John Paul	Project Officer	Directorate of Safety, Health, and Environment (DSHE) ATTN: STEAP-SH-E Building E4430 Aberdeen Proving Ground, MD 21010	(410) 671-4567
Gary McKown	Program Manager ICF Kaiser Engineers	1301 Continental Drive Suite 101 Abingdon, MD 21009	(410) 612-6358
Larry Thebeau	Task Manager ICF Kaiser Engineers	1301 Continental Drive Suite 101 Abingdon, MD 21009	(410) 612-6368
Dave Greer	Project Manager ESE Laboratory	P.O. Box 1703 Gainesville, FL 32602	(904) 333-1608
Jay Kuhn	Quality Assurance Manager ICF Kaiser Engineers	1301 Continental Drive Suite 101 Abingdon, MD 21009	(410) 612-6369
Larry Thebeau	Technical Coordinator, Health and Safety Officer ICF Kaiser Engineers	1301 Continental Drive Suite 101 Abingdon, MD 21009	(410) 612-6368
Debbie Romano	Field Operations Leader ICF Kaiser Engineers	1301 Continental Drive Suite 101 Abingdon, MD 21009	(410) 612-6359
Mike Lowe	Equipment Manager ICF Kaiser Engineers	9300 Lee Highway Fairfax, VA 22031-1207	(703) 934-3621
Kim Mason	Project Data Coordinator ICF Kaiser Engineers	1301 Continental Drive Suite 101 Abingdon, MD 21009	(410) 612-6372

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ADDENDUM I
REFERENCE SAMPLING AND ANALYSIS PROGRAM
FIELD OPERATIONS WORK PLAN
GROUNDWATER SAMPLING AND ANALYSIS
ABERDEEN PROVING GROUND, MARYLAND

FINAL
ICF KAISER
APRIL 1995

ADDENDUM I
REFERENCE SAMPLING AND ANALYSIS PROGRAM
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1.0 INTRODUCTION

The Aberdeen Proving Ground (APG) is conducting extensive environmental study and remediation work to address environmental contamination problems created by historical activities. The Reference Sampling and Analysis Program (RSAP) was established to provide and evaluate data concerning the background concentrations of elements and ubiquitous anthropogenic contaminants in the environment. The RSAP has already considered surface water, sediment, and soil, and is now addressing groundwater.

2.0 BACKGROUND

The original draft workplan proposed the sampling of 20 wells in the coastal plain area adjacent to APG. Twelve of the wells exist and were installed by the Maryland Geological Survey as part of work to support development of water resources for Harford County. The remaining eight wells would have been installed for the RSAP. The planned number of wells to be sampled was not based on statistical calculations. The revised draft workplan suggested that only existing wells be used for the RSAP, and that some wells onpost at APG be considered for use as background. Recent discussions between personnel of APG, regulatory agencies, the US Geological Survey (USGS), and ICF Kaiser have led to the conceptual approach that:

- Only existing offpost wells will be used.
- One round of groundwater samples will be collected from the wells for analysis.
- The focus of the effort will be Target Analyte List (TAL) inorganics, radioactive isotopes (gross alpha and beta), and total uranium. Some select water quality parameters¹ will also be measured to support data evaluation and interpretation. Target Compound List (TCL) compounds will not be addressed.
- The data generated from sampling and analysis of groundwater will be supplemented to the extent possible by use of existing groundwater quality data from sampled wells and also other existing wells.

Discussions with APG project management personnel have also resulted in decisions to:

- Collect samples from monitoring wells using low flow sampling procedures; and
- Analyze only unfiltered samples to determine total concentrations of analytes.

The purpose of this technical memorandum is to present an approach for establishing background for groundwater which is consistent with these concepts.

¹The selected water quality parameters will include chloride, fluoride, sulfate, nitrate, nitrite, total dissolved solids, and total suspended solids.

3.0 TECHNICAL APPROACH

3.1 GENERAL

The sampling of groundwater to characterize background concentrations of analytes must consider two primary factors. The offpost wells for sampling should be selected such that:

- The groundwater at the selected sites provides data which represent the range of groundwater conditions which may be found at onpost study sites.
- The construction of the well does not influence analyte concentrations in collected groundwater samples.

3.2 GROUNDWATER QUALITY CRITERIA

The concentrations of analytes which must be determined at study sites and in background media is in large part determined by health risk based criteria and cleanup criteria for the analytes. The Environmental Protection Agency (EPA) Region III risk-based concentrations (RBCs) for inorganic analytes in tap water are presented in Table 1 (EPA 1994). This table also presents the maximum contaminant levels (MCLs) and detection limits for these analytes using various analytical methods. The anticipated detection limits for the selected methods are underlined in Table 1 and are less than RBCs for all analytes except arsenic and beryllium. The RBCs for arsenic and beryllium are very low because EPA believes these chemicals induce cancer at very low levels. There are no practical analytical methods to achieve detection limits lower than the RBCs for arsenic and beryllium. The detection limits using graphite furnace/atomic adsorption (GFAA) are lower than MCLs for arsenic and beryllium, and are considered acceptable for risk assessment purposes. The Contract Laboratory Procedure (CLP) methods selected for this project will be consistent with the methodologies being used in Remedial Investigation/Feasibility Study (RI/FS) work at APG.

3.3 EXISTING GROUNDWATER QUALITY DATA

Existing data provides some information concerning background groundwater quality. The principal sources of data of reliable quality are studies by the USGS, the Maryland Geological Survey (MGS), and operators of public water supply systems using groundwater. Data from upgradient and uncontaminated wells in the Canal Creek and Nike Site areas of APG are also provided for comparison. These existing data have been used in planning the groundwater sampling and analysis effort. For example, the planned number of samples to be collected was determined using estimates of analyte mean and variance based on existing data. The comparison of onpost and offpost data was also made to determine if there were substantial differences which would indicate potential problems in representing onpost groundwater quality with offpost sampling and analysis.

3.3.1 USGS Delmarva Peninsula Water Quality Assessment

In 1986, the USGS Water Resources Division initiated a regional groundwater quality study addressing the coastal plain aquifers of the Delaware, Maryland, and Virginia (Delmarva) peninsula. The study uses four networks of wells. The areal network primarily addresses the surficial unconfined aquifer and consists of 65 wells at 34 sites. Typical configuration places one well near the water table and another well just above the first encountered confining unit. Another network consists of wells along five east-west transects across the peninsula, screened in the surficial aquifer. The fourth network targets local watersheds with various land usages. The USGS has analyzed groundwater from these wells for a wide range of inorganic and organic analytes. The analyte list includes all TAL metals except thallium, but all determinations for metals were for dissolved (filtered) concentrations.

Table 1 Risk/Regulatory Criteria Levels and Detection Limits for Groundwater						
Analyte	EPA Reg III Tap Water RBC (ug/L)	MCL (ug/L)	Detection Limits (ug/L) ^a			
			ICP ^b	ICPMS ^c	GFAA ^d	CVAA ^b
Aluminum	---	50-200 ^e	<u>45</u>			
Antimony	15	6	32	1.0	<u>3.0</u>	
Arsenic	0.038 ^f	50	53	1.0	<u>1.0</u>	
Barium	2,600	2,000	<u>2</u>			
Beryllium	0.016 ^f	4	0.3		<u>0.2</u>	
Copper	1,400	1,300 ^g	<u>6</u>			
Cadmium	18	5	<u>4</u>		0.1	
Chromium III ^h	37,000	100	<u>7</u>		1.0	
Chromium VI	180	---				
Lead	---	15 ⁱ	7	1.0	<u>1.0</u>	
Manganese	180	200 ^g	<u>2</u>			
Mercury	11 ^j	2				<u>0.2</u>
Nickel	730	100	<u>15</u>			
Selenium	180	50	75	1.0	<u>2.0</u>	
Silver	180	100 ^k	7	0.1	<u>0.2</u>	
Thallium	2.9	2	40	1.0	<u>1.0</u>	
Vanadium	260	20 ^k	<u>8</u>	1.0		
Zinc	11,000	2,000 ^k				

^aSelected method shown in underlined type.

^bUSEPA CLP SOWILM03.0 estimated detection limits using inductively coupled argon plasma spectrometry or cold vapor and atomic adsorption spectrometry.

^cESE USAEC Method S301 Certified Reporting Limits using inductively coupled plasma mass spectrometry.

^dUSEPA CLP-M SOW ILM03.0 estimated detection limits using graphite furnace atomic adsorption spectrometry.

^eSecondary MCL

^fCarcinogenic effects.

^gMCLG

^hDetection limits are for total chromium.

ⁱAction level (exceeded if more than 10% of targeted tap samples are greater than value).

^jBoth inorganic and methyl forms of mercury.

^kEPA drinking water health advisory

--- No value available.

The USGS data have not yet been published, but the data from the areal network and the northernmost transect were obtained for review and analysis. These include roughly 80 sets of analyses from approximately 75 wells.

3.3.2 MGS Study of Harford County Coastal Plain

During the late 1980s and early 1990s the MGS performed a study of the coastal plain aquifers of Harford County (Drummond and Blomquist 1993). The study included installation of monitoring wells and presents limited groundwater quality data for approximately 50 monitoring and water supply wells. Analytes included the metals magnesium, calcium, sodium, potassium, iron, and manganese. Data for iron and manganese are for both dissolved and total concentrations, while all other metals data are for dissolved concentrations. Data for additional TAL metals are presented only for four wells, and are for dissolved concentrations. Drummond and Blomquist (1993) indicate that waters of the coastal plain aquifers in Harford County are mildly acidic, low in dissolved solids concentrations, and that the groundwater chemistry is variable throughout the coastal plain. They also indicate that a regional water quality problem is the presence of iron and manganese in concentrations which exceed EPA secondary maximum contaminant levels (SMCLs).²

Analysis of the MGS data shows that the 95% confidence interval (CI) for the mean concentration of total manganese is less than the EPA Region III RBC and Maximum Contaminant Level Goal (MCLG) for total manganese in Potomac Group groundwater. However, these criteria levels for manganese fall within the 95% CI for total manganese in Talbot Formation groundwater. The single value reported for manganese in Quaternary Alluvium groundwater also exceeds the criteria. The limited Drummond and Blomquist (1993) data for other TAL metals (dissolved) do not indicate mean background concentrations at or above RBCs (except arsenic and beryllium).

3.3.3 Drinking Water Monitoring by Harford County and the City of Aberdeen

Harford County operates well fields in the Perryman and Joppatowne areas, and the community of Aberdeen also obtains drinking water from wells. Both Harford County and Aberdeen perform sampling and analysis required by the Safe Drinking Water Act. Most of the analyses which Aberdeen has accomplished are for finished water, and such data do not necessarily represent raw groundwater quality. Harford County analyzes groundwater from their production wells semiannually for priority pollutants, which include most metals. In addition, samples collected monthly are analyzed for a limited range of parameters which include iron and manganese. Recent data for two sets of priority pollutant analyses for both the Perryman wells and the Joppatowne wells were obtained from Harford County.

3.3.4 Data Summary

The data for metals concentrations in groundwater from the USGS Delmarva study and the MGS Harford County coastal plain study are summarized individually for each analyte in the following paragraphs. Table 2 summarizes the existing USGS/MGS groundwater quality data for the Delmarva and Harford County areas. Data for metals in water samples from Harford County water supply wells in the Perryman and Joppatowne well fields are summarized in Table 3.

Onpost monitoring wells have been identified as background for risk assessment at the former Nike Site, and the USGS also identified wells considered to be uncontaminated and upgradient of contaminant sources in the Canal Creek area. The metals data for samples from these Nike Site and

²The SMCLs for iron and manganese are 300 ug/L and 50 ug/L, respectively.

<p align="center">Table 2 Summary of Existing USGS/MGS Groundwater Quality Data</p>					
Analyte	EPA Reg III Tap Water RBC (ug/L)	MCL (ug/L)	Existing USGS/MGS Data Summary		
			Frequency of Detection	Range (ug/L dissolved)	Number ^a Exceeding RBC or MCL
Aluminum	---	50-200 ^b	47/84	<10 - 2,200	4
Antimony	15	6	5/80	<1 - 3	
Arsenic	0.038 ^c	50	19/80	<1 - 21	
Barium	2,600	2,000	77/80	<2 - 560	
Beryllium	0.016 ^c	4	11/80	<0.5 - 8	2
Copper	1,400	1,300 ^d	27/80	<10 - 360	
Cadmium	18	5	18/80	<1 - 5	1
Chromium III	37,000	100	5/80	<1 - 6	
Chromium VI	180	---	---	---	
Lead	---	15 ^e	4/80	<10 - 40	3
Manganese	180	200 ^d	115/121	<1 - 4,900	29
Mercury	11 ^f	2	3/80	<0.1 - 0.2	
Nickel	730	100	17/80	<1 - 90	
Selenium	180	50	19/80	<1 - 14	
Silver	180	100 ^g	11/80	<1 - 3	
Thallium	2.9	2	---	---	
Vanadium	260	20 ^g	0/76	<6	
Zinc	11,000	2,000 ^g	59/80	<3 - 1,100	

^aComparison to lowest of RBC or MCL except for arsenic and beryllium where comparison is to MCL.

^bSecondary MCL

^cCarcinogenic effects.

^dMCLG

^eAction level (exceeded if more than 10% of targeted tap samples are greater than value).

^fBoth inorganic and methyl forms of mercury.

^gEPA drinking water health advisory

--- No data available.

Table 3 Summary of Groundwater Quality Data for Harford County Production Wells			
Analyte	Frequency of Detection	Range ug/L	Number Exceeding RBC or MCL^a
Aluminum	---	---	
Antimony	4/16	<1 - 5, <19.2	4 (all ND <19.2)
Arsenic	0/16	<1 - <1.97	
Barium	---	---	
Beryllium	0/16	<0.8 - <2	
Cadmium	0/16	<0.260 - <0.5	
Chromium	12/16	<1 - 10	
Copper	15/16	<1 - 179	
Lead	15/16	<1 - 20	1
Manganese	---	---	
Mercury	1/16	<0.2 - 0.2	
Nickel	16/16	3 - 17	
Selenium	5/16	<1 - 2.98	
Silver	0/16	<0.8 - <1	
Thallium	0/16	<1 - <4.60	4 (all ND <4.60)
Zinc	16/16	5 - 13	

^aComparison to lowest of RBC or MCL except for arsenic and beryllium where comparison is to MCL.

--- No data available.

Canal Creek wells are summarized in Table 4 and Table 5. The range of concentrations and frequency of detection in samples from onpost wells are generally consistent with the results of the USGS and MGS studies. Although the Canal Creek and Nike Site data provide an indication of natural concentrations for metals in some onpost areas, they are not likely to represent the full range of onpost natural groundwater quality.

3.3.4.1 Aluminum. Aluminum is detected in roughly half of the regional groundwater samples, and detected concentrations only infrequently exceed the SMCL. The concentrations of dissolved aluminum in the Delmarva study samples ranged from less than detection (10 ug/L) to 2,200 ug/L, with detected concentrations in about half of the samples. Only four of the aluminum concentrations in Delmarva study samples exceed 200 ug/L. Dissolved aluminum concentrations in the four samples reported by the MGS (1993) ranged from <10 to 80 ug/L.

3.3.4.2 Antimony. Antimony is infrequently detected, with dissolved concentrations less than the RBC and MCL levels. Antimony was detected (>1 ug/L) in 5 of 76 Delmarva study samples, with the maximum detected value being 3 ug/L. Antimony was detected in none of the four MGS (1993) samples of Harford County groundwater.

3.3.4.3 Arsenic. Arsenic is detectable in roughly one fourth of groundwater samples from the coastal plain aquifers and does not exceed the MCL of 50 ug/L. Dissolved arsenic was detected (>1 ug/L) by the USGS in 18 of 76 Delmarva samples and 1 of 4 Harford County samples, with a maximum concentration of 21 ug/L. It is likely that coastal plain groundwaters at all locations contain arsenic at concentrations exceeding the RBC of 0.038 ug/L.

3.3.4.4 Barium. Barium is detectable in most coastal plain groundwater samples, but at concentrations substantially below the RBC and MCL levels. Dissolved barium was found in 74 of 76 Delmarva study samples at concentrations above the detection limit of 2 ug/L, and in 3 of 4 Harford County samples above 100 ug/L. The highest concentration detected was 560 ug/L.

3.3.4.5 Beryllium. Beryllium is detectable in a small fraction of coastal plain groundwater samples, with concentrations infrequently exceeding the MCL. Dissolved beryllium was detected (>0.5 ug/L) in 10 of 76 Delmarva study samples and 1 of 4 Harford County samples, with the maximum concentration being 8 ug/L. Two of the samples had concentrations exceeding the MCL of 4 ug/L. It is likely that beryllium concentrations in groundwater at all locations in the coastal plain exceed the EPA RBC of 0.016 ug/L.

3.3.4.6 Copper. Copper is detectable in more than one third of groundwater samples, but at concentrations substantially less than RBC and MCL levels. Dissolved copper is present at concentrations above the detection limit of 10 ug/L in 23 of 76 Delmarva samples, and in all 4 Harford County samples above 4 ug/L. The maximum detected concentration was 360 ug/L.

3.3.4.7 Cadmium. Cadmium is detectable in a fraction of coastal plain groundwaters, with concentrations rarely exceeding the MCL. Dissolved cadmium was found above the 1 ug/L detection limit in 18 of 76 Delmarva study samples and 0 of 4 Harford County samples, with the maximum concentration of 5 ug/L being the only value exceeding the 4 ug/L MCL.

3.3.4.8 Chromium. Chromium is detected only infrequently in coastal plain groundwaters, and at concentrations well below the RBC and MCL levels. Dissolved chromium was found (>5 ug/L) in 2 of 76 Delmarva study samples, with the detectable concentrations being 6 ug/L. In Harford County samples, dissolved chromium was found (>1 ug/L) in 3 of 4 samples, with the maximum level being 4 ug/L.

<p align="center">Table 4 Metals Concentrations in Upgradient Potomac Group Wells at Nike and Canal Creek Areas</p>						
Analyte	Filtered			Unfiltered		
	Frequency of Detection	Range (ug/L)	Number Exceeding RBC or MCL ^a	Frequency of Detection	Range (ug/L)	Number Exceeding RBC or MCL ^a
Aluminum	4/17	<10 - 230	4 ^b	1/2	<121 - 3760	1 ^c
Antimony	2/25	<1 - 4		---	---	
Arsenic	1/28	<1 - 1, <5		0/13	<3.7 - <5	
Barium	3/14	6 - 58		3/3	22 - 32.8	
Beryllium	0/20	<0.7 - <10		2/6	<0.7 - 6.2	1
Cadmium	10/34	<1 - 9	3	2/9	<2.4 - 8.52	2
Chromium	6/34	<1 - 10, <50		1/7	<8.8 - 9.23	
Copper	5/34	<1 - 17.2, <22		0/8	<17.2 - <20.8	
Lead	5/25	<0.98 - 6		2/3	<0.98 - 19.2	1
Manganese	33/34	<5.2 - 2400	11	9/9	36.5 - 256	4
Mercury	1/24	<0.2 - 0.4, <0.5		0/9	<0.2	
Nickel	11/30	<8, 1 - 52		0/8	<22.3 - <28.9	
Selenium	0/34	<1 - <4.3		0/8	<4.3	
Silver	0/11	<0.3 - <1		---	---	
Thallium	3/7	<40 - 50	3 ^d	---	---	
Vanadium	0/8	<10.7 - <21.3		1/9	<12.5 - 50.9	1
Zinc	20/26	<2 - 2400	1	1/2	<18.3 - 221	

^aComparison to lowest of RBC or MCL except for arsenic and beryllium where comparison is to MCL.

^bNine of the samples had non-detect values above the MCL (Range: <96.2 - <160).

^cOne sample had a non-detect value above the MCL (<121).

^dAll of the non-detect samples were above the MCL.

--- No data available.

Table 5 Metals Concentrations In Upgradient Surficial Aquifer Wells at Nike and Canal Creek Areas						
Analyte	Filtered			Unfiltered		
	Frequency of Detection	Range (ug/L)	Number Exceeding RBC or MCL ^a	Frequency of Detection	Range (ug/L)	Number Exceeding RBC or MCL ^a
Aluminum	0/8	<96.2 - <121	all ND are above MCL	0/6	<96.2 - <121	all ND are above MCL
Antimony	1/3	<3 - 7	1	---	---	
Arsenic	0/10	<3.7 - <18.5		1/13	<1 - 3, <3.7	
Barium	3/3	32.5 - 60.3		3/3	33.2 - 61.2	
Beryllium	0/9	<0.7 - <10		0/8	<0.7 - <0.8	
Cadmium	1/13	<2.4 - 6	1	1/10	<2.4 - 14.3	1
Chromium	0/13	<1 - <9.1		1/9	<8.8 - 16.3	
Copper	2/13	<1 - 4, <20.8		0/10	<17.2 - <20.8	
Lead	3/7	<0.98 - 4		2/4	<0.98 - 6.8	
Manganese	13/13	18.8 - 680	3	10/10	17.2 - 422	2
Mercury	0/13	<0.2 - <0.5		0/10	<0.2	
Nickel	2/12	<1 - 15, <28.9		0/9	<15.5 - <28.9	
Selenium	0/13	<1 - <4.3		0/10	<4.3	
Silver	---	---		---	---	
Thallium	---	---		---	---	
Vanadium	0/10	<10.7 - <21.3		0/9	<12.5 - <21.3	
Zinc	3/3	46 - 60		0/2	<18.3	

^aComparison to lowest of RBC or MCL except for arsenic and beryllium where comparison is to MCL.

--- No data available.

3.3.4.9 Lead. Only a small fraction of groundwater samples contain detectable lead, and concentrations may infrequently exceed the EPA action level (for water supply systems) of 15 ug/L. Dissolved lead was present in 4 of 76 Delmarva and 0 of 4 Harford County groundwater samples, with a maximum level of 40 ug/L.

3.3.4.10 Manganese. Manganese is present at detectable concentrations in most coastal plain groundwater samples. A significant fraction of samples have concentrations which exceed the RBC. Dissolved manganese was found in 72 of 76 Delmarva study samples above the detection limit of 1 ug/L, with 2,200 ug/L being the maximum level detected. In Harford County samples, dissolved manganese was present above the detection limit in 43 of 45 samples, with a maximum concentration of 4,900 ug/L. Total manganese was determined for 54 Harford County samples with a detection limit of 10 ug/L. Manganese was detected in 46 of these 54 samples, with the maximum concentration being 4,800 ug/L. The RBC of 180 ug/L was exceeded in 29 of 121 filtered samples from the two areas. The mean concentrations of total and dissolved manganese in Harford County samples were 266 and 274 ug/L, respectively, while the standard deviations were 771 and 792 ug/L. The means of the filtered and unfiltered data sets were compared and not determined to be statistically different.

3.3.4.11 Mercury. Only a very small fraction of coastal plain groundwater samples contain detectable mercury, with concentrations below both the RBC and the MCL. Dissolved mercury was found (>0.1 ug/L) in 1 of 76 Delmarva samples at a concentration of 0.2 ug/L. In Harford County samples, 2 of 4 had detectable mercury, also at a concentration of 0.2 ug/L.

3.3.4.12 Nickel. A small portion of coastal plain groundwater contains detectable nickel, with maximum concentrations near the MCL of 100 ug/L. Fourteen of 76 Delmarva study samples contained dissolved nickel above the detection limit of 10 ug/L, with a maximum concentration of 90 ug/L. The detection limit for the Harford County study was lower (1 ug/L) and 3 of 4 samples contained detectable dissolved nickel, with the highest concentration being 15 ug/L.

3.3.4.13 Selenium. Selenium is detected in a small fraction of coastal plain groundwater samples at concentrations below the RBC and MCL. The USGS/MGS found dissolved selenium in 18 of 76 Delmarva and 1 of 4 Harford County samples above the detection limit of 1 ug/L. The maximum concentration was 14 ug/L.

3.3.4.14 Silver. A small fraction of groundwater samples contain detectable silver, with concentrations well below the RBC and MCL levels. Eleven of 76 Delmarva samples and 0 of 4 Harford County samples had dissolved silver above the detection limit of 1 ug/L. The maximum concentration was 3 ug/L.

3.3.4.15 Thallium. The USGS Delmarva study and the MGS Harford County study did not analyze samples for thallium.

3.3.4.16 Vanadium. Concentrations of vanadium are generally not detected in coastal plain groundwater and are less than RBC and MCL levels. No vanadium was detected in 76 Delmarva study samples, with a detection limit of 6 ug/L. The MGS Harford County study did not analyze samples for vanadium.

3.3.4.17 Zinc. Most coastal plain groundwater contains detectable levels of zinc, but at concentrations below criteria levels. Dissolved zinc was present in 55 of 76 Delmarva and 4 of 4 Harford County study samples, with an analytical detection limit of 3 ug/L. The maximum concentration was 1,100 ug/L.

3.4 SAMPLE DESIGN

3.4.1 General

In risk assessment, study site data will be compared to background data using statistical procedures to identify those analytes which are above background and therefore are contaminants of concern. Study site concentrations may also be compared to RBCs or to MCLs during decision making processes. When a data set is to be compared statistically to either another data set or to a particular value, the minimum number of data values (samples) which must exist in the data set is dependent on the variability of the parameter being measured, the relative difference which must be detected, and the required confidence level (1- α) and power (1- β) of the statistical test. Higher population variance, decreasing the relative difference to be detected, and decreasing α and/or β all increase the number of required samples in a sampling design.

3.4.2 Sample Design Stratification

The USGS and MGS data for the Delmarva and Harford County areas indicate that, for at least some analytes, concentrations are dissimilar for groundwater from different aquifers. For analytes with background concentrations similar to the RBC and/or regulatory criteria, the most appropriate approach is to address the individual aquifers as separate sampling strata. Later in risk assessment, study site groundwater data may then be compared only within sampling strata. For example, the risk assessor may choose to compare groundwater quality data for wells screened in the Quaternary sediments only to background data for groundwater from these sediments.

3.4.3 Estimation of Required Number of Samples

For analytes which are either normally or lognormally distributed, an estimate of the minimum number of samples required to detect a specified relative difference given a known coefficient of variation, confidence level, and power is obtained from the formula (EPA 1989):

$$n \geq [(Z_{\alpha} + Z_{\beta})/D]^2 + 0.5Z_{\alpha}^2$$

where "n" is the minimum number of samples, " Z_{α} " and " Z_{β} " are t distribution values for the given α and β for infinite degrees of freedom, and "D" is the minimum relative detectable difference divided by the coefficient of variation.

From a decision making standpoint, the most critical relative difference which must be detectable is that between the background concentration and the risk or regulatory criteria for the analyte. The statistical determination that study site concentrations are above background is of much greater importance when the study site concentrations are also above the risk/regulatory criteria. The MGS/USGS data for dissolved concentrations of metals in groundwater in the Harford County and Delmarva peninsula areas can be used as an indicator of concentration ranges which may be seen in unfiltered samples of groundwater in the APG area. Many of the USGS/MGS dissolved concentrations for manganese exceeded both the RBC and MCLG for that element. It is likely that concentrations of arsenic and beryllium in all groundwater exceeds the RBCs, but only a fraction of samples had detectable levels and only a very small fraction of these samples had levels above the MCLs. Other metals with detection limits relatively close to the RBC or MCL and which could possibly require detection of small relative differences in statistical testing are antimony, cadmium, lead, mercury, and thallium. The USGS and MGS data may also be used to provide an initial estimate of the coefficient of variation for metals concentrations in groundwater.

As an example of calculations to determine required number of samples, consider manganese in Harford County groundwater of the Potomac Group and Talbot Formation as reported by Drummond and Blomquist (1993). Manganese concentrations are lognormally distributed in both filtered and unfiltered groundwater samples (Shapiro-Wilks test). The mean and standard deviation of total manganese (unfiltered samples) is shown in Table 6. Figure 1 displays the 95% confidence interval for total manganese in these aquifers, and for the Talbot Formation the upper end of this interval is higher than both the RBC and the MCLG. Assuming desired α and β of 0.05 and a minimum relative detectable difference equal to the difference between the mean and the RBC of 180 mg/L, and using natural log transformed data, the required number of samples as determined by the above equation is 4 for the Potomac Group and 78 for the Talbot Formation. This example illustrates the sensitivity of the required number of samples to the relative difference which must be detected. The required confidence and power of the test also influence the number of required samples, with a reduction from 78 to 47 if confidence and power of 90% is desired instead of 95%.

In risk assessment, the site data will not simply be compared to a particular number or criteria. The site data will first be compared to the background data set. If the data are normally (or lognormally) distributed and the two data sets have equal population variances, the operating characteristic curve for the t test may be used to estimate the number of required samples. For the example of manganese in groundwater of the Potomac aquifer and with $\alpha = \beta = 0.05$, the required number of samples is approximately 12 for both the study site and background. From a purely statistical standpoint, collection of an equal number of samples at the study site and for background will result in the minimum number of total samples being collected.

The number of required samples may also be influenced by other factors. For example, because spatial relationships exist in groundwater quality, the collection of samples from several wells screened in the same aquifer and located in a relatively small area will not be as useful as collection of samples from widely separated wells.³ If wells selected for sampling are located in groups, with the wells in each group in close geographic proximity, the total number of required samples is increased. The quality of groundwater can be represented by the fewest number of samples when the wells are widely spaced over the area being studied.

The target number of samples for this study is 15 to 18 for each sample design stratum. This number is expected to provide a background data set which is adequate for manganese in Potomac Group groundwater, and is also adequate for all other analytes in groundwater of both Cretaceous and Quaternary sediments. The collection of 15 to 18 samples will ensure that a suitable number of background values are available, even if several samples must be eliminated from the data set as outliers or because of other factors. As discussed above, available data suggest that manganese may be the only analyte where a statistical difference between background and the site concentrations cannot be detected when site concentrations exceed the RBC and/or the MCLG ($\alpha = \beta = 0.05$).⁴

3.5 EXISTING WELLS

3.5.1 Information Sources

Information concerning existing monitoring wells has been obtained from several sources. The USGS maintains a database which includes a wide range of information, including that related to well

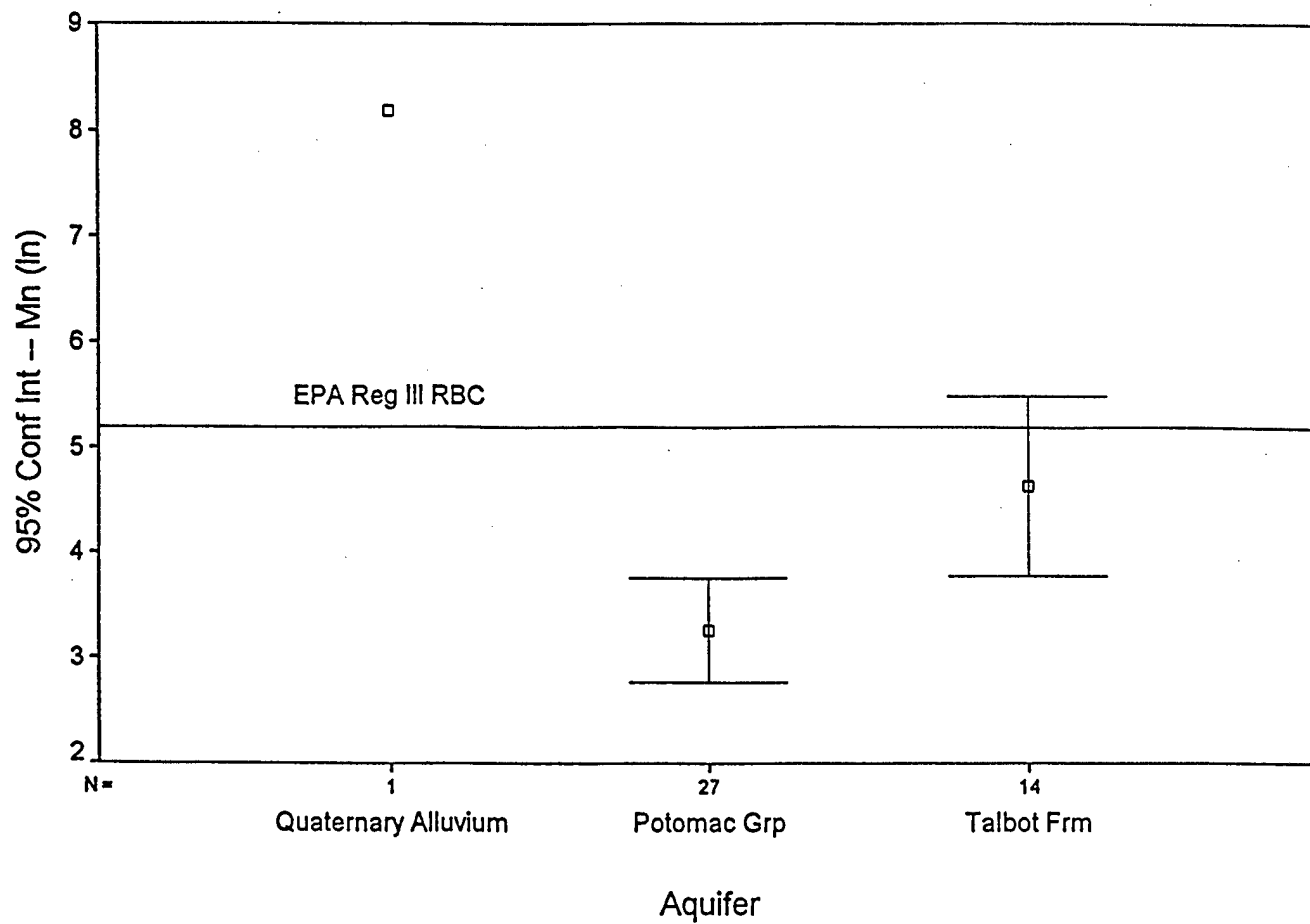
³Classical statistical procedures assume that all samples are independent. Data from wells in close proximity may not be independent.

⁴Comparison of arsenic and beryllium to MCLs and not RBCs.

Table 6
Manganese in Groundwater
Harford County Coastal Plain
(mg/L)

	Cretaceous Aquifers	Quaternary Aquifers
Mean / Standard Deviation	66.4 / 93.6	327 / 783
Natural Log Mean / Standard Deviation	3.41 / 1.28	4.63 / 1.49

Manganese in Groundwater



Data Source: Maryland Geological Survey, 1983

Values are natural log transformation of total manganese concentrations.

location, construction and, in some cases, water quality. Records concerning more than 800 wells were obtained from this database, with wells located in the coastal plain area of Baltimore, Harford, and Cecil Counties in Maryland. The Maryland Department of the Environment issues permits for new wells and also maintains a database of this permit information. The state permit records are only for wells installed since roughly 1960, when permitting requirements were established. The electronic version of neither database is completely up-to-date with all wells installed in recent years. For example, many of the wells installed during the late 1980s as part of the MGS study of the Harford County coastal plain groundwater are not yet in the USGS database. Because of this limitation, neither of these electronic databases by themselves are an effective tool for identifying existing wells which may be sampled. The State permit system is an effective means of obtaining general information concerning particular wells for which the permit number is known. Drilling method and date, construction materials, screen interval, and a lithologic summary are information items obtainable from the permits.

One of the most valuable sources of information concerning existing wells used for domestic, commercial, industrial, and public water supply purposes are county government offices. While these offices do not maintain extensive electronic or paper file databases on existing wells, they are knowledgeable of groundwater usage and can identify those areas where all or some residents have domestic wells. Local government personnel are also knowledgeable concerning the existence of monitoring wells which have been installed for groundwater studies.

Another valuable source of information concerning existing domestic wells is the well survey report recently prepared for Aberdeen Proving Ground [ASI 1994]. This survey used the electronic databases and also a mail survey to identify privately owned wells in the eastern Baltimore and Harford County areas near the installation.

The final methods used to find recently installed domestic wells were visual inspection of neighborhoods with domestic wells to identify new homes and interview of residents in these areas.

For wells identified from either the databases, county offices, the well survey, or neighborhood surveys, additional information was necessary to determine if a well may be suitable for sampling to establish background concentrations. The necessary additional information includes construction details and materials for the well, site usage information, and well usage information. This information was obtained through contact with the well owner and the drilling firm which installed the well.

The search for existing monitoring and domestic wells which may be suitable for sampling as part of the RSAP has been extensive. The criteria established for selection of wells resulted in identification of only a small number of acceptable wells, especially those screened in Quaternary sediments. Considerable effort would be required to identify any additional wells which may be suitable.

3.5.2 Monitoring Wells

Monitoring wells provide the best source for groundwater sampling because they are designed and constructed to produce samples which are representative of groundwater quality. Monitoring wells may be installed in a wide range of groundwater conditions, including those where groundwater is naturally of poor quality. Therefore, monitoring wells are more likely to provide data on the complete range of groundwater quality than are production wells or privately owned domestic wells (for reasons to be discussed later in this section). In this respect, monitoring wells will be most representative of the groundwater encountered in studies at APG. In addition, water may be sampled directly from the well, which is not the case with existing production and domestic wells that are being considered for sampling.

The monitoring wells located offpost which may be considered for reference program sampling include wells installed by MGS throughout Harford County as part of the 1993 Coastal Plain study, wells installed by USGS on the Delmarva peninsula, wells installed for the purposes of studying groundwater quality or providing leak detection at underground storage tank (UST) sites, and wells/piezometers installed to monitor water levels at wetland mitigation sites.

The MGS installed 18 monitoring wells in uncontaminated areas as part of the Harford County Coastal Plain study. A portion of these wells are in clusters of two or three wells screened at different depths.

The USGS Delmarva Peninsula study investigates approximately 75 wells which include already existing wells and monitoring wells installed by USGS. Although the Delmarva Peninsula is part of the coastal plain, the distance from APG and the different aquifers in this area may result in different groundwater chemistry. For example, the available data show the dissolved concentrations of manganese to be different for these aquifers and different from the Potomac Group and Talbot Formation in Harford County. There are several wells along the western edge of the Delmarva peninsula which are in the area where the Kent Island Formation is found. The Kent Island Formation is or Pleistocene in age and similar to the Talbot Formation in Harford County. Owens and Denny (1979) do not differentiate between the Kent Island and Talbot formations, acknowledging both as being deposited under estuarine fresh water conditions. The length of the groundwater flow path will be short for these Kent Island Formation wells, as are the flow path lengths for the shallow Talbot Formation wells in Harford County. These wells are considered suitable as background for shallow groundwater from Quaternary system sediments.

Wells which have been installed for studying contaminated sites or known leaking underground storage tanks are not being considered for this sampling effort due to the fact that the groundwater at these sites is potentially contaminated. Many fuel stations are located along the Route 40 corridor and have been in service for many years. Long term fuel storage including leaded gasoline, use of solvents involved in maintenance operations, and spillage and discarding of these materials are all factors which create concern with sampling at such sites. Although some of the monitoring wells have been installed upgradient of any contamination, the uncertainty is too great to justify the time, money and effort for sampling at these locations. It should also be noted that many "wells" installed for leak detection at UST sites are not actually wells, but rather are vapor monitoring "pipes" which extend only to a depth of roughly two feet beneath the UST bottom and do not penetrate groundwater. Another potential disadvantage of selecting monitoring wells at sites which are potentially contaminated is the possibility that it may be difficult to obtain permission to sample such wells.

A search was conducted for monitoring wells which may have recently been installed at new UST sites in newly developed areas. At a site such as this, the groundwater would most likely be uncontaminated because of only very recent storage and use of hazardous and other chemical materials. No such sites were found in the coastal plain area of Harford and Baltimore Counties.

Monitoring wells have also been installed as part of studies prior to facility construction. Both Clorox and the Baltimore Gas and Electric Company (BG&E) installed monitoring wells at their facilities near the Aberdeen Area of APG. Most of the wells installed by Clorox have since been closed, and only one still exists as a monitoring well. BG&E installed approximately 60 monitoring wells prior to construction of their Perryman power plant. Most of these wells still exist and they have subsequently installed additional wells to investigate groundwater contamination. Only a portion of the BG&E wells are being considered for use in the RSAP because (1) the site has substantial groundwater contamination problems due to leakage of fuel tanks, and (2) at least a portion of the site may be

downgradient of APG property. Furthermore, BG&E may not grant permission for sampling of their wells.

Wells/piezometers have also been installed in both Harford and Baltimore Counties at sites where wetlands are being established as part of wetland mitigation projects. The State Highway Administration installed approximately 9 shallow 2-inch diameter polyvinyl chloride piezometers near Route 40 and Route 715. Two additional wetlands sites in Harford County are within the Bush Declaration National Resources Management Area near James Run and Route 7. The piezometers at both of these sites are very shallow and constructed of 1-inch PVC. Another wetlands mitigation site with monitoring wells is located in the Back River Neck area of Baltimore County near Rocky Point Park.⁵

If constructed appropriately, groundwater samples from these shallow wells and piezometers at wetlands mitigation sites could provide excellent background information for shallow monitoring wells installed in marsh areas at APG study sites. The principal disadvantage for use of these wells/piezometers are the uncertainties concerning procedures used for installation. These wells and piezometers have been installed only for obtaining water level measurements. The normal procedures used for installing monitoring wells for obtaining samples may not have been employed in drilling and installation of these piezometers. For example, the procedures for grout placement may have introduced grout into the screened section of the annular space, influencing chemistry of the groundwater in the vicinity of the piezometer. Such a situation would not be detectable by a site surface inspection, and may not be detectable by examination of the well permit and drilling logs. Because of these uncertainties, piezometers at wetland mitigation sites will not be sampled for the RSAP.

3.5.3 Public Water Supply Wells

Production wells for public water supply pump large volumes of water, and data from sampling these wells would be representative of groundwater quality over a substantial area and aquifer thickness. This is in contrast to monitoring wells which provide groundwater quality data for only the small aquifer volume around the screen.

The sampling of a production well has both advantages and disadvantages over a monitoring well. The average concentration of analytes in groundwater in the area of influence of the well will be better represented by samples from the production well. However, the variability of analyte concentration between points in the aquifer which can be measured by sampling monitoring wells cannot be as effectively determined from production well samples. The principal disadvantage of using production wells to establish background is that these wells may not accurately represent the complete range of groundwater quality being studied at APG. This is the case because the locations and screen intervals are selected to maximize production volume and quality, and therefore only groundwater of acceptable quality will be obtained from production wells. This contrasts with monitoring wells which are normally not biased to locations and depths of relatively good quality.

Although production wells are constructed with metal casings and screens, groundwater quality would not be adversely affected by construction materials due to the continuous use and pumpage of very large quantities of water. Groundwater sampled from these wells as part of the

⁵This is a wetlands mitigation project being developed by BG&E. While BG&E has installed monitoring wells, the project has otherwise not yet been initiated and they are currently negotiating for purchase of the land. Contact with BG&E personnel has determined that they are reluctant to grant permission for sampling where they do not own the property.

RSAP would be collected during routine use at a tap closest to the well and before any treatment of the water.

Public water supply wells provide water for both Harford County and the Town of Aberdeen. The County operates wells in two fields in the Joppatowne and Perryman areas. There are eight wells in the Perryman field and four wells in the Joppatowne field which either are currently being used or have been used recently. The Town of Aberdeen also operates 11 wells, all located on APG property. The Harford County wells pump water from the Potomac Group, as do some Aberdeen wells. Other Aberdeen wells are screened in the Talbot Formation. Many of the Perryman wells and Town of Aberdeen wells are either located on APG property or are located on the installation boundary. Groundwater pumped by some of the Perryman wells are contaminated with trichloroethylene released by historical Army activities at the former fire training area adjacent to Phillips Army Airfield.⁶ The groundwater pumped by several Town of Aberdeen wells is also contaminated with low levels of volatile organic compounds. Currently active production wells at which groundwater is not contaminated have been considered for Reference Program sampling.

3.5.4 Privately Owned Wells

Domestic wells have also been evaluated for groundwater sampling. As is the case with public water supply wells, domestic wells are typically screened in aquifers which have a reasonable yield and good quality water. Thus, domestic wells may not represent the full range of groundwater quality being studied at APG. However, as for production wells, groundwater from these wells will accurately represent the quality of water used by residents of local communities. The bias toward groundwater of relatively good natural quality which is introduced by using domestic wells also has advantages as well as disadvantages. One advantage is that this bias is conservative and more protective in that statistical comparison of APG study site data to domestic well data is more likely to show concentrations above background. The most important comparisons to background and decisions concerning remediation will be made for those APG study sites where groundwater is of naturally good quality and suitable for potable use if not contaminated. In such situations, the most appropriate background to use for comparison may be the biased background provided by domestic wells.

Privately owned domestic wells that are chosen for sampling must meet several requirements. Wells must be constructed of plastic casings and screens, and piping from the well into the house up to the first tap must also be plastic. The well screen must not be installed using a lead seal. In addition, the reservoir in the house must be constructed with a liner and/or bladder such that the water does not contact metal tank surfaces except at fittings.⁷ One of the most important selection screening criteria is age of the well since most domestic wells that meet the above requirements have

⁶The Army is currently treating groundwater extracted from these wells to reduce trichloroethylene to levels below the MCL prior to distribution for public use.

⁷Most water system reservoirs which have been encountered in our investigation thus far are Well-X-Trol tanks manufactured by Amtrol. These reservoirs are cylindrical steel tanks with FDA approved butyl rubber diaphragms and NSF listed polypropylene liner. In a reservoir such as this, groundwater enters the tank through a 1 inch copper-lined water acceptance fitting. According to Amtrol, copper analyses on water going through this fitting have been performed and concentrations have been non-detect. Once inside the tank, water only comes in contact with the butyl rubber diaphragm and the polypropylene liner. Rupturing or leakage of the diaphragm is readily detected because the air charge is lost and this will cause the pump to start short cycling and the faucets to work improperly.

been installed within the past five years. Another criterion for well selection will be routine and frequent usage by the owner. Routine usage will reduce the likelihood of pump or water system construction materials influencing sample quality.

The groundwater sample will not be collected directly from the well because of the risk of introducing bacterial contamination. Instead, the well will be sampled from the first tap within the system. Most recently installed domestic water systems have a tap immediately after the "T" connecting the reservoir to the water system, with the piping in the system prior to the tap being plastic. The well construction materials and specifications will be determined by review of the State of Maryland well permit and by contacting the driller to verify that a lead seal has not been used with the screen installation. Water system materials and tap location will be determined by inspection of the system from the point of entry into the home to the tap which will be used for sampling.

The sampling will be accomplished after a time of heavy water use (showers, laundry, lawn watering) in order to ensure that the water in the tank has been purged and filled with fresh groundwater. When the sample is collected, additional water from the system will be purged at the tap until the reservoir is emptied and begins to refill. The sample will then be collected, minimizing any impact of the water reservoir on sample quality.

Water for homes in various areas in both Harford and Baltimore Counties is obtained from domestic wells. Domestic wells supply all water in certain portions of the Back River Neck and Middle River areas in Baltimore County, and also in some areas of Harford County. The areas where domestic wells supply all water are generally those where there has been limited residential development beyond the extent of the public water supply system.

- The southern portion of the Back River Neck area is not supplied with public water and all water is obtained from domestic wells. Land usage in the northern part of this area is primarily agricultural and woodland with a small number of residential homes. Essex Skypark is a lightly-used airfield and base for light aircraft, and is found on the west side of the neck. The southernmost portion of the Back River Neck is wooded with homes along portions of Barrison Point Road, Island View Road, Rocky Point Road, Riverview Road, Wildwood Beach Road, Evergreen Lane, Beachwood Avenue, and Bayside Road. Rocky Point Park is found at the southern tip of the neck and contains a golf course area. The boring logs from well permits indicate that clayey sands are found to a depth of 5 to 30 feet and are underlain by 20 to 70 feet of clay and sandy clay. Wells are screened beneath the clay in the sand of the Patapsco Formation. The site usage, the locations of homes, and the geology of the site make contamination of groundwater at these domestic well sites unlikely.
- Homes in portions of the Middle River area west of Carroll Island and Graces Quarters obtain water from domestic wells. Most of these areas are either wooded or combined wooded and agricultural. Residential homes are found along the roads, mostly in the water front areas. While some domestic wells are shallower than 100 feet, many are 100 to 200 feet in depth, with a few being deeper. These wells obtain water from the Patapsco Formation, except for deeper wells in the northwest part of the area which penetrate the Patuxent Formation.
- In the Harford County area north of the Edgewood Area of APG homes with domestic wells are found along Trimble Road, Fort Hoyle Road, Magnolia Road, and Nuttal Avenue. Most of these wells are screened in Potomac Group sediments, but some shallower wells may draw water from the Talbot Formation.

- The area adjacent to the Aberdeen Area of APG also has localities in which homes obtain water from wells. In the Perryman area, homes on Park Beach Drive have domestic wells. Domestic wells are also found in the area of Newton Road southeast of Aberdeen. In the area east of Aberdeen, all of the homes on Country Club Road have domestic wells. Shallow wells in these areas are screened in the Talbot, while those which are deeper are in the Potomac Group. Most of the wells along Country Club Road are less than 75 feet in depth and are screened in the Talbot Formation. Country Club Road surrounds a golf course which is located adjacent to Swan Creek. The golf course has used small amounts of copper sulfate to control algae in ponds and has also used small quantities of pesticides containing zinc and manganese for spot application. The movement of shallow groundwater will be from the golf course area toward the domestic wells and Swan Creek. Several homes on Creek Road at the south end of the area are located such that the groundwater obtained from shallow wells would not be impacted by golf course activities.

3.6 WELL SELECTION AND EXISTING DATA USAGE SUMMARY

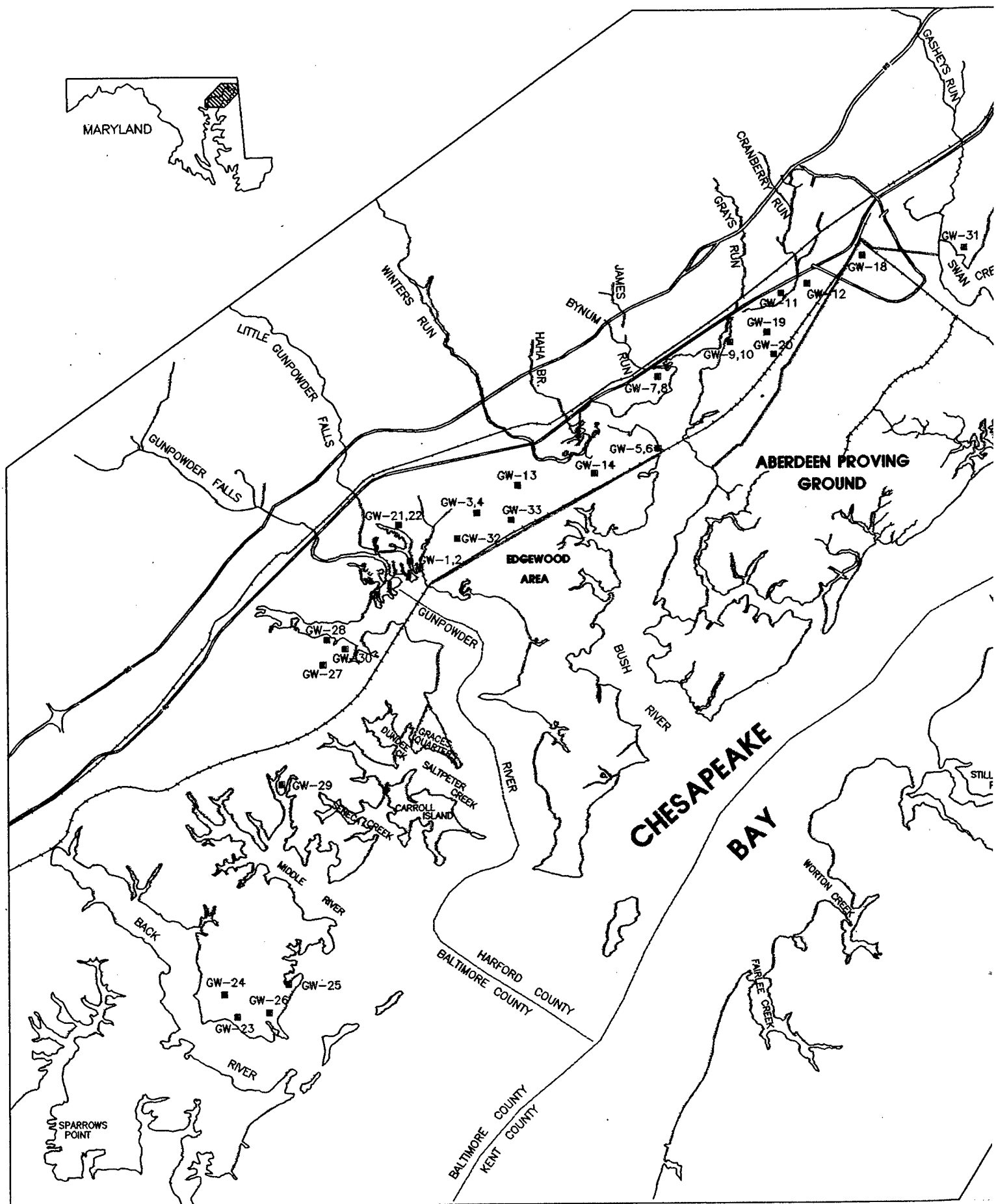
Variation in natural groundwater quality is found both between aquifers and within a particular aquifer at different geographical locations and depths. The mineralogy of aquifer material and the age of the groundwater are both factors which influence groundwater chemistry. Age of groundwater is related to length of the flow path from the recharge area. Groundwater in shallow Quaternary sediments will typically have short flow paths, be recent in age, and be relatively unmineralized with low dissolved solids concentrations. Groundwater in Potomac Group sediments will be similar at locations near outcropping recharge areas, but may be more mineralized with higher dissolved solids at locations where the aquifer is deeper and the flow path from the point of recharge is longer. The natural groundwater quality is expected to be most similar for two sites when they are located in the same aquifer and along the same strike line. For example, representative background for relatively deep confined Potomac Group groundwater at a study site on APG may be better obtained by sampling groundwater in similar hydrologic conditions from wells along the strike line southwest of APG in Baltimore County than by sampling Potomac Group groundwater closer to the recharge area in Harford County.

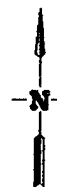
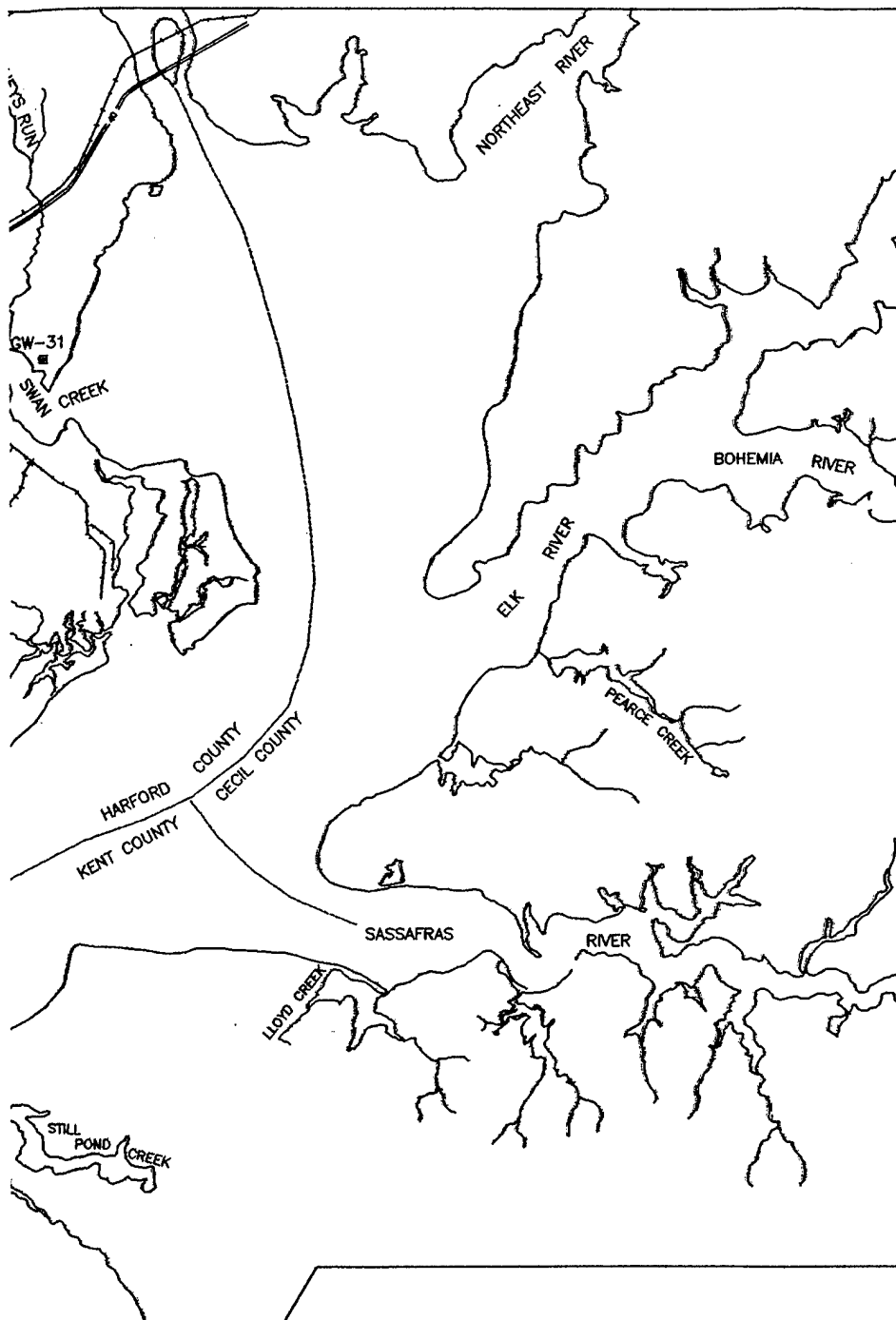
The chemistry of groundwater in the coastal plain sediments is reported to be highly variable (Drummond and Blomquist 1993). This spatial variability and the large size of APG suggest that a wide range of natural groundwater chemistry conditions may exist onpost. In order to represent the full range of onpost conditions, the offpost sampling locations should also be distributed throughout a relatively wide geographic area on the coastal plain.

3.6.1 Cretaceous Wells

Natural background chemistry for groundwater in Potomac Group sediments of Cretaceous age will be determined by sampling 18 wells: 6 MGS monitoring wells in Harford County, 4 domestic wells on the lower portion of the Back River Neck area in Baltimore County, 4 domestic wells in the Middle River area of Baltimore County, and 4 Harford County water supply wells in the Perryman and Joppatowne well fields. The locations of these wells are shown on Figure 2. Table 7 provides summary information including well depth and screen interval.

This combination of monitoring wells, domestic wells, and production wells will provide data over a broad geographic area for groundwater ranging in depth from 50 feet to 210 feet. The two production wells in each of the two well fields are located in close proximity to each other, but are screened at different depths. The Perryman wells selected do not include those contaminated by historic activities at the fire training area.





LEGEND

- COUNTY LINE
- MAJOR ROAD
- INSTALLATION BOUNDARY
- + + RAILROAD TRACKS
- GW-11 GROUNDWATER SAMPLING LOCATION

NOTE: GW-15, GW-16, AND GW-17 ARE LOCATED FURTHER SOUTH ON THE DELMARVA PENINSULA IN QUEEN ANNES (GW-15) AND DORCHESTER COUNTIES (GW-16,17).

0 5000 FEET



0 1500 METERS



US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DAAA15-91-D-0014

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CHECKED DR

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DATE 02-08-95

REFSAMP3

FIGURE 2

ABERDEEN PROVING GROUND

REFERENCE

GROUNDWATER

SAMPLING LOCATIONS

<p align="center">Table 7 Groundwater Well Locations and Construction Details</p>							
ICF KE Sampling Number	Well Location	State ID/MGS Well Designation	Date Installed	Well Depth (ft)	Top of Screen (ft)	Screen Length (ft)	Age of Screened Interval
Monitoring Wells							
GW-1	Mariner Point Park	HA-81-4125/ HA Ec 47	11-21-87	20	3	10	Quaternary
GW-2	Mariner Point Park	HA-81-4124/ HA Ec 46	11-20-87	85	65	10	Cretaceous
GW-3	Trimble Road	HA-81-4129/ HA Ed 49	03-21-88	23	13	10	Quaternary
GW-4	Trimble Road	HA-81-4578/ HA Ed 48	03-17-88	128	118	10	Cretaceous
GW-5	Gum Point	HA-81-4135/ HA De 182	12-22-87	40	30	10	Quaternary
GW-6	Gum Point	HA-81-4577/ HA De 183	12-19-87	165	155	10	Cretaceous
GW-7	Long Bar Harbor	HA-81-4137/ HA Dd 92	02-05-88	38	18	10	Quaternary
GW-8	Long Bar Harbor	HA-81-4136/ HA Dd 91	01-28-88	78	58	10	Quaternary
GW-9	Fords Lane	HA-81-4576/ HA De 199	01-22-88	29	9	10	Quaternary
GW-10	Fords Lane	HA-81-4140/ HA De 197	01-22-88	85	75	10	Cretaceous
GW-11	Cranberry Road	--/HA De 187	1987	17	7	10	Quaternary
GW-12	Cranberry Run Business Park	HA-81-4142/ HA De 195	01-20-88	45	35	10	Quaternary
GW-13	Edgewood Elementary School	HA-81-4130/ HA Dd 89	12-08-87	150	96 120	10 10	Cretaceous
GW-14	Willoughby Woods	HA-81-4522/ HA Dd 106	06-28-88	210	190	10	Cretaceous
Delmarva Monitoring Wells							
GW-15	Queen Annes County	QA-81-2983/ QA Fd 03	06-16-88	19	16	3	Quaternary
GW-16	Dorchester County	--/DO Ce 89	05-01-89	18	15	3	Quaternary
GW-17	Dorchester County	DO-81-1261/ DO Cb 08	06-14-88	14	11	3	Quaternary
Production Wells							
GW-18	Aberdeen Well Field #6	HA-93-0090	05-09-94	50	32	18	Quaternary

Table 7
Groundwater Well Locations and Construction Details

ICF KE Sampling Number	Well Location	State ID/MGS Well Designation	Date Installed	Well Depth (ft)	Top of Screen (ft)	Screen Length (ft)	Age of Screened Interval
GW-19	Perryman Well Field #1	HA-66-0814/ HA De 73	07-28-66	103	94	9	Cretaceous
GW-20	Perryman Well Field #4	HA-70-0086/ HA De 59	12-11-69	144	96	48	Cretaceous
GW-21	Joppatowne Well Field #4	HA-04-6966/ HA Ec 12	06-15-62	97	57	40	Cretaceous
GW-22	Joppatowne Well Field #8	HA-04-6968/ HA Ec 14	08-06-62	166	146	20	Cretaceous
Domestic Wells -- Back River Neck Area							
GW-23	Kasinski/Gribble 2201 Riverview Rd.	BA-88-3352	06-20-91	58	51	7	Cretaceous
GW-24	Barbagallo 1301 Evergreen Ln.	BA-92-0459	05-07-92	57	50	7	Cretaceous
GW-25	Donovan 2502 Island View Rd.	BA-92-0199	03-13-92	89	82	7	Cretaceous
GW-26	Porter 2024 Rocky Point Rd.	BA-92-0325	04-10-92	84	77	7	Cretaceous
Domestic Wells -- Middle River Area							
GW-27	Bayne 945 Bird River Beach Rd.	BA-92-0331	05-21-92	50	43	7	Cretaceous
GW-28	Bess 6732 Mallard Rd.	BA-88-2570	07-24-90	45	38	7	Cretaceous
GW-29	Arnett 222 Stevens Rd.	BA-92-0216	03-04-92	114	109	5	Cretaceous
GW-30	Kron 6854 Leslie Rd.	BA-88-1170	06-14-89	50	43	7	Cretaceous
Domestic Wells -- Harford County Area							
GW-31	Earnshaw 914 Creek Rd.	HA-92-0760	02-19-93	65	58	7	Quaternary
GW-32	Whittington 117 Ft. Hoyle Rd.	HA-92-0224	06-16-92	89	82	7	Quaternary ^a
GW-33	Necker 1803 Nuttal Ave.	HA-88-1372	10-29-90	45	38	7	Quaternary ^a
Alternate Locations							
--	Hollandsworth 124 Magnolia Rd.	HA-93-0334	03-07-94	100	93	100	Cretaceous

<p align="center">Table 7 Groundwater Well Locations and Construction Details</p>							
ICF KE Sampling Number	Well Location	State ID/MGS Well Designation	Date Installed	Well Depth (ft)	Top of Screen (ft)	Screen Length (ft)	Age of Screened Interval
--	Boone 2042 Park Beach Drive	HA-88-2032	11-14-91	75	68	7	Cretaceous
--	Roz 2000 Park Beach Drive	HA-88-2005	10-10-91	140	133	7	Cretaceous
--	Shank 616 Trimble Rd.	HA-88-1857	07-30-91	60	53	7	Cretaceous
--	Merkey 116 Ft. Hoyle Rd.	HA-93-0020	08-25-93	101	81	20	Quaternary ^a

^a Age of the screened interval is difficult to determine and may either be Quaternary or upper Cretaceous.

3.6.2 Quaternary Wells

Samples from 15 wells will be obtained to provide background data for groundwater in Quaternary sediments. These wells include 8 MGS monitoring wells in Harford County; 3 USGS monitoring wells on the eastern shore in Queen Annes and Dorchester Counties; 3 domestic wells in Harford County; and 1 Town of Aberdeen production well. The locations of these wells and summary information are also provided in Figure 2 and Table 7.

These wells are also spatially distributed over a broad geographic area ranging from eastern shore areas to north of the Town of Aberdeen. The depth of these wells ranges from 14 feet to 89 feet. It should be noted that the depth of the contact between the Quaternary and Cretaceous sediments is not precisely known at most locations and some of the domestic wells may actually be screened in shallow Cretaceous sediments instead of the Talbot Formation of the Quaternary system. This uncertainty is not critical because in either case the groundwater flow paths are short and groundwater chemistry is expected to be similar.

3.6.3 Existing Data Usage

The existing data of the MGS, USGS, and Harford County have been used in planning this effort, but are generally not adequate for use in the RSAP. Most of the USGS and MGS data are for dissolved (filtered) rather than unfiltered samples and is not appropriate for use in risk assessment comparisons. The Harford County data for groundwater from production wells is from unfiltered samples, but the analyte list does not include all TAL metals. It may be possible and appropriate to use some of the Harford County and MGS data from unfiltered sample analysis for certain analytes such as manganese. This possible use of existing data will be further considered after data from the planned RSAP groundwater sampling and analysis is available.

3.6.4 Supplemental Sampling

This sampling plan has been designed to provide data from a single sampling event which is adequate to support risk assessment and related decision making. If review of the data from this RSAP effort or other remedial investigation work determines that additional reference background data for groundwater is necessary, such supplemental sampling and analysis will be accomplished after appropriate planning and coordination.

3.7 FIELD AND LABORATORY METHODS

The field and laboratory methods to be employed for this groundwater sampling and analysis are specified in the revised QAPjP. The SOPs in the QAPjP have been taken from the standardized and approved generic workplan SOPs with little or no revision.

Most of the groundwater sampling currently being accomplished at APG is performed using low flow sampling procedures developed by the EPA Robert S. Kerr Environmental Research Laboratory. These low flow sampling procedures will be used for sampling of all monitoring wells for the RSAP. All chemical analyses will be performed with only unfiltered samples. Chemical analyses will be accomplished using EPA procedures, with CLP methods being used for metals determinations as indicated in Table 1.

4.0 REFERENCES

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ATTACHMENT

REFERENCE SAMPLING AND ANALYSIS PROGRAM
FIELD OPERATIONS WORK PLAN
DRAFT FINAL DOCUMENT
NOVEMBER 1993
RESPONSE TO COMMENTS
BY
U.S. ENVIRONMENTAL PROTECTION AGENCY

1. General

Comment: *It seems reasonable to sample for the full suite of TAL and TCL constituents in the analytical program for all of the environmental media. Please provide justification for performing the limited analyses listed in this work plan.*

Response: All TCL Semivolatiles will be analyzed for in surface soil, and this has been added to the workplan. TCL Volatiles were originally added to the list of groundwater analyses based on this comment, however, plans for groundwater sampling and analysis have changed since that time, and TCL Volatiles have been taken off the list of analyses. Please see Addendum I of this document for details on groundwater sampling.

Many compounds are temporal in nature and should only be sampled at the same time as sampling occurs for the Remedial Investigation in order to provide a valid comparison of contaminant levels.

Many of the compounds being analyzed for in sediment for the reference program are the same as those being done in the Remedial Investigation. Volatiles and some of the semivolatiles are not being analyzed for since they are not known or suspected to be ubiquitous contaminants in these media.

2. Section 3.1.2

Comment: *Please provide additional clarification for the statement cited in Section 3.1.2 which states that, "local background concentrations which are higher than ubiquitous concentrations will be assumed to originate from a local source on or adjacent to APG and will be addressed by upgradient sampling and analysis as part of the individual remedial investigations effort."*

Response: This statement has been changed to state that, "local on-post background concentrations which are higher than ubiquitous concentrations will be assumed to originate from a local source on or adjacent to APG and will be addressed by upgradient sampling and analysis as part of the individual remedial investigations effort."

3. Section 3.1.3

Comment: *Please use the Risk Based Concentration Tables and the Region III Guidance document for the screening of potential contaminants of concern and for the determination of site media of concern for the identification of contaminants at levels for which there is a potential for concern rather than MCL or state drinking water standards. Many of these standards are not totally health based and may pose risks at unacceptable levels to receptors. (Section 3.1.3)*

Response: The EPA Region III Risk Based Concentration Table will be used for identifying levels of contaminants for residential soil and groundwater use. Section 3.1.3 and Addendum I for groundwater sampling and analysis have been changed to note the source of these screening levels.

4. Section 3.1.4
Comment: *It is suggested that the Region's Risk Based Concentration Tables be used to help select the analytical methods for this activity. (Section 3.1.4)*
Response: The EPA Region III Risk Based Concentration Table will be used to select the analytical methods.
5. Page 3-6
Comment: *Please provide additional documentation for the statements made concerning pesticide usage at APG (page 3-6). It is recommended that more extensive pesticide characterization be conducted if adequate documentation is not provided.*
Response: Pesticides at APG are not being detected at levels which are significant contributors to risk. The RSAP is using the same methodology for pesticides as is being used for the study sites at APG. The work plan will remain unchanged.
6. General
Comment: *It is suggested that SQLs be used in data reporting when ever possible and/or appropriate. CRQLs and CRDLs have very little practical use in many instances.*
Response: CRQLs and CRDLs are routinely used in reporting data for the RI. However, SQLs will be provided by ESE, and the use of both SQLs and 1/2 the concentration of the CRQLs and CRDLs will be evaluated for those parameters where detection limits are relatively close to criteria levels.
7. Table 3-3
Comment: *The noncarcinogenic criteria cited in Table 3-3 and other similar tables are in some cases several orders of magnitude too high. Please refer to the Risk Based Concentration Tables and make appropriate changes in these tables.*
Response: Table 3-3 has been changed to reflect the correct values using the Risk Based Concentration Table.
8. Table 3-11
Comment: *The drinking water standards found in table 3-11 may not be protective of human health. Lead no longer has an MCL of 0.050 ppm. The action level for lead is 15 ppb. Please make the appropriate change. In addition the MCL for arsenic cited in the table is not protective of human health. An increased cancer risk due to the ingestion of arsenic i(n) drinking water of 1.0E-06 is calculated for a concentration of 0.038 ppb and an HI of 1.0 is calculated for a concentration of 11 ppb.*
Response: Groundwater quality data have been changed to show the action level for lead (15 ppb) and the levels for arsenic (0.038 ppb carcinogenic, and 11 ppb noncarcinogenic). All drinking water standards (except lead) have been changed to reflect the values shown in the EPA Region III Risk Based Concentration Table. These changes can be found in Addendum I.

REFERENCE SAMPLING AND ANALYSIS PROGRAM
FIELD OPERATIONS WORK PLAN
DRAFT FINAL DOCUMENT
NOVEMBER 1993
RESPONSE TO COMMENTS
BY
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

1. Page 3-3
Comment: *Please add grain size, TOC, acid volatile sulfides (AVS), simultaneously extracted metals (SEM), and pore water salinity to Table 3-1. Justification for this comment is provided in later comments.*
Response: Grain size and TOC have been added to Table 3-1. AVS/SEM and pore water salinity were only analyzed at two of the reference locations and were performed in conjunction with sampling for the O-Field Remedial Investigation. These parameters will not be added since they are not part of the RSAP sampling effort.
2. Page 3-6
Comment: *In some areas of APG, DDT is a contaminant of concern.*
Response: Up to the present, DDT has not been determined to be a problem. The work plan will remain unchanged.
3. Page 3-7
Comment: *The use of the term "onpost" may not be appropriate here. Reference locations should adequately represent environmental media that are affected by releases from APG.*
Response: Since Remedial Investigation activities are intended to assess contamination of areas that are part of APG (or in close proximity to APG) due to APG activities, the term "onpost" is fit to describe the locations for which reference sites should represent. It is also important to note that the property boundaries for APG extend far and encompass the Gunpowder River and the Bush River.
4. Page 3-25
Comment: *In order to evaluate the effect of total suspended solid (TSS) concentrations on contaminants in surface water, reference samples with a broad range of TSS concentrations should be collected.*
Response: Surface water locations have been selected to represent similar salinity, flow regimes, and bottom lithologies to surface water at or downgradient of APG. Total suspended solids were not used as a main characteristic to determine representative reference sites. A preliminary look at the surface water data shows that a wide range of TSS concentrations were encountered during sampling.
5. Page 3-38
Comment: *Since the sediment analyses at individual study areas will include AVS and SEM measurements, it would be appropriate to include these measurements on reference samples.*
Response: Analyses for AVS/SEM are only needed when bioassays are performed at sites. Bioassays at reference locations should only be performed at the same time as bioassay analyses at study sites since they are temporal in nature. Bioassays were performed at select reference locations because bioassays were being done for some Watson Creek sediment locations at the same time. Since these analyses were performed for a study site, they will not be included in the RSAP work plan.

6. Tables 3-8 and 3-9

Comment: Please change the fourth column heading to indicate that these numbers are not biological effects criteria. A more appropriate title for the column would be biological effects indicators or guidelines. The notes should also be changed.

Response: The work plan has been revised to reflect these changes.

7. Page 3-33, paragraph 1

Comment: ER-L and ER-M values published by Long and Morgan (1990) are not NOAA criteria for the protection of biota. This may seem like a fine distinction, but NOAA does not promulgate these values for the use described in this paragraph. I would prefer that you describe these values as screening guidelines that indicate the potential for adverse biological effects.

Response: This has been corrected in the work plan.

8. Page 4-2

Comment: Surface water should be sampled from deeper than a few inches below the water surface. If surface water is contaminated it may be as a result of sediment contamination or from groundwater discharge into surface water. Effluent discharges can result in contamination of the surface layer but any outfalls should be easily located and avoided. I would recommend sampling water from a few feet above the sediment surface.

Response: It is important to realize that most of the surface water sites are shallow, therefore sampling a few feet above the sediment is impossible. Additionally, sampling near the sediment makes it difficult to not disturb the sediments. Collecting surface water several inches beneath the surface for all sites is also consistent with the sampling procedure used for surface water locations that are part of the RI effort.

9. Page 4-2

Comment: Add odors and obvious signs of biota to the list of sediment parameters noted during sampling.

Response: These parameters have been added to the work plan.

10. Page 5-1

Comment: According to the schedule given here, soil sampling begins in December. This does not allow much time to incorporate comments, since they are due on December 28.

Response: The schedule has been revised in the work plan.

REFERENCE SAMPLING AND ANALYSIS PROGRAM
FIELD OPERATIONS WORK PLAN
DRAFT FINAL DOCUMENT
NOVEMBER 1993
RESPONSE TO COMMENTS
BY
MARYLAND DEPARTMENT OF THE ENVIRONMENT

1. Page 3-2, Contaminants in the Environment

Comment: *How will the Risk Assessment deal with the synergistic or cumulative effects of ubiquitous environmental contaminants with respect to site specific contamination? Should the regional level of contamination be considered when evaluating site specific contaminants of concern?*

Response: The purpose of the risk assessment is to evaluate potential impacts to human health and ecological receptors from the presence of site-related chemicals. The potential risks from ubiquitous environmental contaminants will not be evaluated as part of the risk assessment if these chemicals are not also site-related (i.e. present on-site at higher concentrations than in the background). If a ubiquitous environmental contaminant is also site-related then the risk from the total detected chemical concentration will be evaluated. Further, any synergistic or potentiating effects known to occur between ubiquitous environmental contaminants and site-related contaminants will be qualitatively evaluated or discussed to the extent possible.

There is one exception to the general rule of evaluating only site-related chemicals. Toxicity testing, which is being conducted at many of the study areas for the ecological risk assessment, determines the toxicity of all chemicals in a tested media (including ubiquitous environmental contaminants) and it is not possible to screen out or account for the toxicity of non site-related chemicals when using such an evaluation technique.

2. Page 3-4, Section 3.1.3

Comment: *Maryland's drinking water standards are by law no more stringent than the Federal standards. Therefore it is recommended that the Federal standards be used as "concentrations of concern."*

Response: Drinking water standards in the RSAP have been changed to the values shown in the EPA Region III Risk Based Concentration Table (Third Quarter 1994), except for lead, which has been changed to the EPA action level of 15 ppb. These screening criteria can be found in Addendum I.

3. Page 3-6, Section 3.1.5

Comment: *In addition to "ubiquitous" anthropogenic organic compounds which are directly attributable to site activity, shouldn't the Risk Assessment also address "ubiquitous" anthropogenic organic compounds which may act cumulatively or synergistically with site specific "contaminants of concern?" Shouldn't the overall contaminant "load" in the region be considered?*

Response: Please refer to Response 1.

4. Page 3-36, Table 3-11

Comment: *The title of the table is "Drinking Water Standards." Please specify the source of these "standards." The EPA's current "Action Level" for lead is significantly lower than the value defined in the table.*

Response: Drinking water standards in the RSAP have been changed to the values shown in the EPA Region III Risk Based Concentration Table (Third Quarter 1994), except for

lead, which has been changed to the EPA action level of 15 ppb. These screening criteria can be found in Addendum I.

5. Page 4-6, Figure 4-1

Comment: *The intent of the "bentonite seal" above the "filter pack" is to provide a minimum of two (2) feet of low permeability material between the "filter pack" and the "grout." Therefore the diagram should indicate a minimum thickness of two feet and maximum thickness of five feet. As annotated the drawing indicates that any thickness of bentonite that does not exceed five feet is acceptable.*

Response: Based on this comment, Figure 4-1 was originally corrected in the work plan. However, since the time that this comment was made, plans for groundwater sampling and analysis have changed, and this figure has been deleted. Please see Addendum I for details on groundwater sampling and analysis.

6. Page 4-22, Section 4.10.3

Comment: *There appears to be an inconsistency in the management of Investigatory Derived Media (IDM) between this section and Section 4.4.1. It is suggested that both sections be reviewed in light of recent guidance provided to APG addressing IDM.*

Response: If the soil cuttings can not be left on-site, then the cuttings will be containerized and brought to the Westwood Landfill at the Edgewood Area for disposal. No TCLP testing will be necessary since the cuttings will be from uncontaminated areas. Section 4.10.3 in the work plan was initially corrected to reflect this, however since the time that this comment was made and addressed, plans for groundwater sampling and analysis have changed. Soil cuttings were not produced, and therefore, did not present a problem. Please see Addendum I for details on groundwater sampling and analysis.

REFERENCE SAMPLING AND ANALYSIS PROGRAM
FIELD OPERATIONS WORK PLAN
DRAFT FINAL DOCUMENT
NOVEMBER 1993
RESPONSE TO COMMENTS

BY
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE

1. Page 3-3, 1LT Garodnick

Comment: In addition to sediments, surface waters should also be screened for PAH's, pesticides and PCB's, phthalates, etc. as positive findings could indicate ongoing transport from a source at or upgradient of the sampling location. No mention is made of the possibility of surface to ground water flow / contamination. Because of the variability of the regional hydrology, it may be prudent to test the groundwater samples for the analytes listed above.
Recommendation: Screen surface water samples for sediment sample analytes. Determine the impact of surface to ground water flow, and analyze appropriately.

Response: Anthropogenic compounds are temporal in nature in surface water, therefore PAHs, pesticides, PCBs, and phthalates will be analyzed at the same time as sampling for the Remedial Investigation at upgradient sites.

Groundwater locations have been chosen in areas where groundwater, soil and any nearby surface water are believed to be uncontaminated. It is not likely that the groundwater will be contaminated from any surface water flow. These compounds will not be analyzed for as part of the RSAP.

2. Page 3-6, Section 3.1.5, Reference Data Use in Risk Assessment, Mr. Hoddinott:

Comment: This section states that the variance for the study samples and the reference samples is assumed to be identical. This is an error. The t-test can be performed on samplings with different sample variances. To assume that the samples from different site have the same variance ignores one of the more important characteristics of the population.
Recommendation: Delete this assumption from the study.

Response: This discussion intends to state that for the t-test to be valid, the population variance must be equal, not necessarily the sample variance. This has been clarified in the work plan.

3. Page 3-15, Section 3.4.1, Soil - General, Mr. Hoddinott

Comment: This section discusses three influences which affect the development and chemistry of the soil. While these three are important, the remaining factors are just as important. For example, it is only opinion that climate is the most important factor responsible for developing soil into horizons. The role of time can not be ignored.
Recommendation: A full discussion of soil forming factors is not warranted here; however, the text should not leave the reader with the impression that time, biological activity, and topographical placement are not minor.

Response: The work plan has been revised to mention other factors that are also important in soil formation, specifically vegetation cover, soil organisms, topography and time. It is also noted that while some of these factors influence soil development, they are also influenced by climate.

4. Page 3-26, Table 3-6, 1LT Garodnick

Comment: The chronic freshwater ambient water quality criteria for mercury should read 0.000012, not 0.00012.

Recommendation: Make appropriate corrections.

Response: This has been corrected in the work plan.

5. Page 4-22, Section 4.10.3, Soil From Drilling Activities, Mr. Hoddinott

Comment: *I fail to understand why this is necessary. By definition these areas should not be contaminated. The chemical constituents of these soils should not be at levels representative to the area of their collection. While I will not make this item into an issue, the idea that these soils need to be tested violates the entire concept of background sampling.*

Recommendation: *Consider deleting the requirement in the first draft reviewed by the state and EPA.*

Response: Soil cuttings will be left on-site if an agreement can be reached with the site owners. If the soil cuttings can not be left on-site, then the cuttings will be containerized and brought to the Westwood Landfill at the Edgewood Area for disposal. No TCLP testing will be necessary since the cuttings will be from uncontaminated areas. Section 4.10.3 in the work plan was initially corrected to reflect this, however since the time that this comment was made and addressed, plans for groundwater sampling and analysis have changed. Soil cuttings were not produced, and therefore, did not present a problem. Please see Addendum I for details on groundwater sampling and analysis.

REFERENCE SAMPLING AND ANALYSIS PROGRAM
FIELD OPERATIONS WORK PLAN
DRAFT FINAL DOCUMENT
NOVEMBER 1993
RESPONSE TO COMMENTS
BY
DIRECTORATE OF SAFETY, HEALTH AND ENVIRONMENT

1. Page 1-1, John Wrobel
Comment: *Using RSAP data to determine disposal of investigatory derived waste.*
Response: The objectives listed in this document relate to decision making for the Remedial Investigation. The RSAP data can be used to determine disposal of investigatory derived material, but this is a separate issue (waste management).
2. Page 1-2, John Wrobel
Comment: *The RSAP does not need to be completed concurrently with the RI/FS activities at APG.*
Response: This statement will be taken out of the document.
3. SOPs, John Wrobel
Comment: *Referencing the SOPs*
Response: The following statements have been added to Section 4.0 of the Field Operations Work Plan. "All procedures summarized in the Field Operations Work Plan (FOWP) are consistent with APG/WES developed SOPs. The SOPs have been designed to meet EPA, Federal and State technical requirements. All SOPs can be found in the Quality Assurance Project Plan which is a companion document to the FOWP."
4. Page 3-24, John Wrobel
Comment: *J-Field has high lead concentrations in some areas.*
Response: This statement has been changed to read, "For example, the concentrations of lead in the reference soil samples may be higher than those in soils at downrange study sites because of the proximity of the reference sampling sites to major highways."
5. Page 3-42, John Wrobel
Comment: *Why use two methods (low-flow and high-flow rate purging) if you are trying to save money?*
Response: EPA has shown that different values will be obtained by using both low-flow and high-flow rate purging. Separate background values will not be established using both procedures, but use of both procedures will enable the risk assessors to make a comparison between the two methods. Since the time that this comment was made and addressed, plans for groundwater sampling and analysis have changed. Low-flow sampling was the only method used for groundwater sampling. Please see Addendum I for details.
6. Sampling methods, Don Green
Comment: *Sampling methods are not consistent with WES SOPs which should be referenced*
Response: Methods in the work plan are consistent with WES SOPs, and these SOPs can be found in the Quality Assurance Project Plan.
7. Figure 3-1, Don Green
Comment: *Landfill #3 is a large sanitary landfill.*
Response: Figure 3-1 has been changed to reflect this.

REFERENCE SAMPLING AND ANALYSIS PROGRAM
FIELD OPERATIONS WORK PLAN ADDENDUM
GROUNDWATER SAMPLING AND ANALYSIS
ABERDEEN PROVING GROUND, MARYLAND
DRAFT DOCUMENT
OCTOBER 1994
RESPONSE TO COMMENTS
BY
U.S. GEOLOGICAL SURVEY

1. General.

Comment: *Sampling strata design should be based on the additional features of geohydrology and knowledge based on geomorphology. Effort should be made to delineate ground-water drainage basins (at least to the several square mile scale). Autocorrelation of the sample population can be avoided by not placing multiple sampling points within the same ground-water basin. Similarly, sites in up dip or outcrop zones (generally north of APG) of the Cretaceous would tend to be more oxidizing than a site intended to monitor the same zone further down dip. By biasing the data set toward more oxidizing conditions metals concentrations may be uncharacteristically low -- in general, metals are more mobile at lower valence states e.g. reducing conditions.*

Response: We agree with the conceptual content of the comment. The "ideal" background groundwater samples for a particular study site would be from upgradient or crossgradient wells in the same groundwater drainage basin and near the study site. However, decisions to (1) obtain reference groundwater samples from only offpost wells, and (2) to obtain most or all samples from existing wells, places constraints on the approach. The desire to use existing monitoring wells forces consideration of the MGS wells in Harford County, of which the deeper wells are screened in the Cretaceous and up dip of APG. The domestic wells identified for sampling are spread over a wide geographic area, but tend to be located in groups. This grouping is due to the grouping of residences using wells in the areas where there is no public water supply. It should be noted that grouping and autocorrelation may not be significant problems. There is substantial variation in groundwater quality within drainage basins as well as between basins and this variation is known to occur over very short geographical distances. Because both "between basin" and "within basin" variation should be measured by the sampling program, sampling of multiple wells within a drainage basin is reasonable. Both the use of groundwater samples from offpost wells to represent onpost groundwater quality and the use of existing wells have disadvantages as well as advantages. While the disadvantages exist, it is believed that the proposed approach will provide data which will be usable in risk assessment for most APG study sites and for most or all TAL parameters. It is also believed that at the very least the proposed approach is an appropriate first step. Evaluation of the data from this effort will allow design of supplemental groundwater reference sampling, if such sampling is necessary.

2. Section 3.5.2.

Comment: *Sampling sites located in Queen Annes and Talbot Counties on the eastern shore of Maryland are Pleistocene age as stated by Owens and Denny (1979). Locally the formation is known as the Kent Island however, Owens and Denny (1979) do not differentiate between the Kent Island and the Talbot formations, acknowledging both as being deposited under estuarine, fresh water conditions.*

Response: The plan has been revised to more accurately describe the eastern shore sites.

3. Sections 2.0 and 3.2.

Comment: Section 2.0 indicates the sampling will center around the TAL metals and gross alpha and beta. Additional attention should be paid to radon ²²² and uranium. U.S. EPA has identified both radionuclides as health risks and set the SMCL for uranium at 10 pCi/L (picocuries per liter). With the current and historic use of depleted uranium on base, having quantifiable background data on uranium will provide future RI's with a reliable ambient uranium concentration in ground water. Radon contamination of ground water is generally associated with flow paths in igneous and metamorphic material as well as glauconitic clays. The SMCL for radon is, to my knowledge, still at 200 pCi/L. Radon is significant in that both the U^{238} and U^{234} isotopes decay (eventually) to radon ²²². It is important to note that samples taken closer to bedrock -- whether at depth or north of the northern base boundary near the fall line, may have higher ambient levels of radon and uranium.

Response: Analysis for radon and uranium are not currently being performed as part of APG study efforts. While radon is not a likely future analyte, it is very likely that studies at some sites will include analysis of groundwater for uranium. At least a portion of the reference program groundwater samples will be analyzed for uranium using a ICPMS method which will allow determination of U^{235} and U^{238} concentrations, and by addition, total uranium.¹ Because this method measures concentrations of individual isotopes, future use of this method for samples at APG study sites would also allow determination of relative concentrations of the isotopes, and therefore, whether the samples contain depleted uranium.²

4. Section 3.3.1.

Comment: Section 3.3.1, in the second sentence, states "The areal network primarily...". This sentence should be changed to reflect the fact that the networks were broader than what is indicated. A suggested alternative might be "the areal network primarily addresses the surficial unconfined aquifer and consists of 65 wells at 34 sites. Typical configuration places one well near the water table and another well just above the first encountered confining unit."

Response: The plan has been revised as suggested.

5. Section 3.5.4.

Comment: Section 3.5.4, 5th paragraph indicates that domestic wells on Back River Neck screened in Cretaceous sands are unlikely to be contaminated by metals. Caution should be taken to choose only wells upgradient of Rocky Point golf course.

Response: None of wells selected in the Back River Neck area are believed to be downgradient of the golf course.

¹The concentration of U^{234} would not be directly measured because it comprises only 0.0056% of natural uranium and will be below detection limits for this method.

²Natural uranium contains 0.718% U^{235} and 99.276% U^{238} . Depleted uranium contains a smaller proportion of U^{235} .

REFERENCE SAMPLING AND ANALYSIS PROGRAM
FIELD OPERATIONS WORK PLAN ADDENDUM
GROUNDWATER SAMPLING AND ANALYSIS
ABERDEEN PROVING GROUND, MARYLAND
DRAFT DOCUMENT
OCTOBER 1994
RESPONSE TO COMMENTS
BY
MARYLAND DEPARTMENT OF THE ENVIRONMENT

1. Section 2.0, Page 1.
Comment: *The decision to limit analytical parameters to Target Analyte List (TAL), gross alpha, and gross beta is reasonable given the objective of this effort. The TAL and gross alpha and beta parameters should provide legitimate regional values for comparison with the site specific samples collected from the facility. The exclusion of organic parameters is appropriate since organic compounds detected in site specific samples will be related to some anthropogenic source and will necessarily require source identification.*
Response: No response required.

2. Section 3.6, Page 20.
Comment: *The decision to evaluate the groundwater in terms of Cretaceous and Quaternary deposits, while unusual, is acceptable. Furthermore, the proposed number of samples and sample locations are acceptable.*
Response: No response required.